





# Natural Resource Damage Assessment: Fate and Effects of Dispersed Oil

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# Why Consider Dispersants?

- Aerial application of dispersants can mitigate large amounts of oil if treated promptly.
  - Mitigate -- reduce the overall impact of an oil spill to the environment as a whole.
  - However, dispersant use is a **trade-off** with increased risks to the water column balanced against reduced injury to surface water and shoreline resources.



# How do dispersants work?

- The function of dispersants is to reduce the oil-water interfacial surface tension and thereby greatly enhance the transfer of oil droplets from the water surface into the water column, as shown in the following equation.

$$W_K = \gamma_{o/w} A_{o/w}$$

Where:

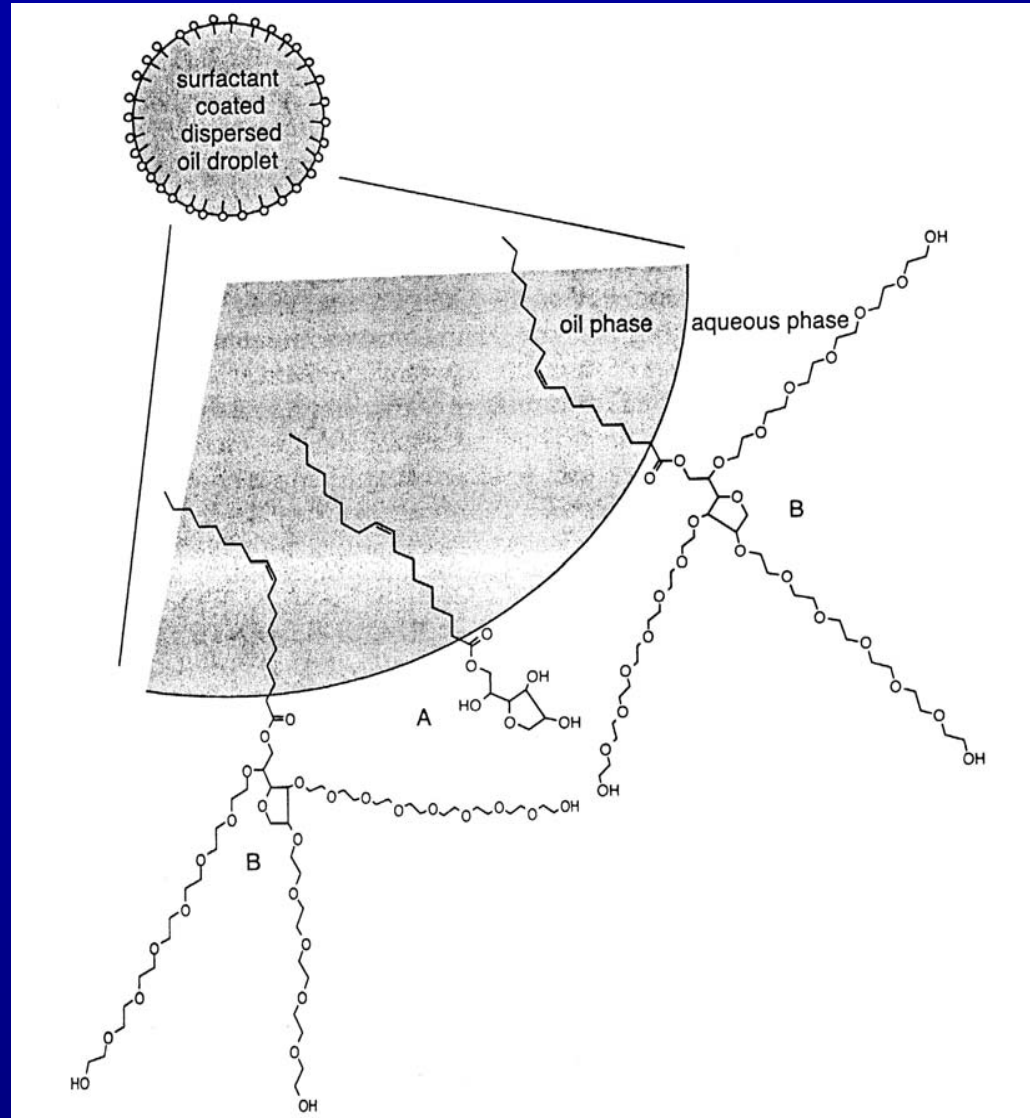
$W_K$  = mixing energy

$\gamma_{o/w}$  = oil-water interfacial surface tension, and

$A_{o/w}$  = oil-water interfacial surface area.

# Just Like Dawn® Dish Washing Detergent?

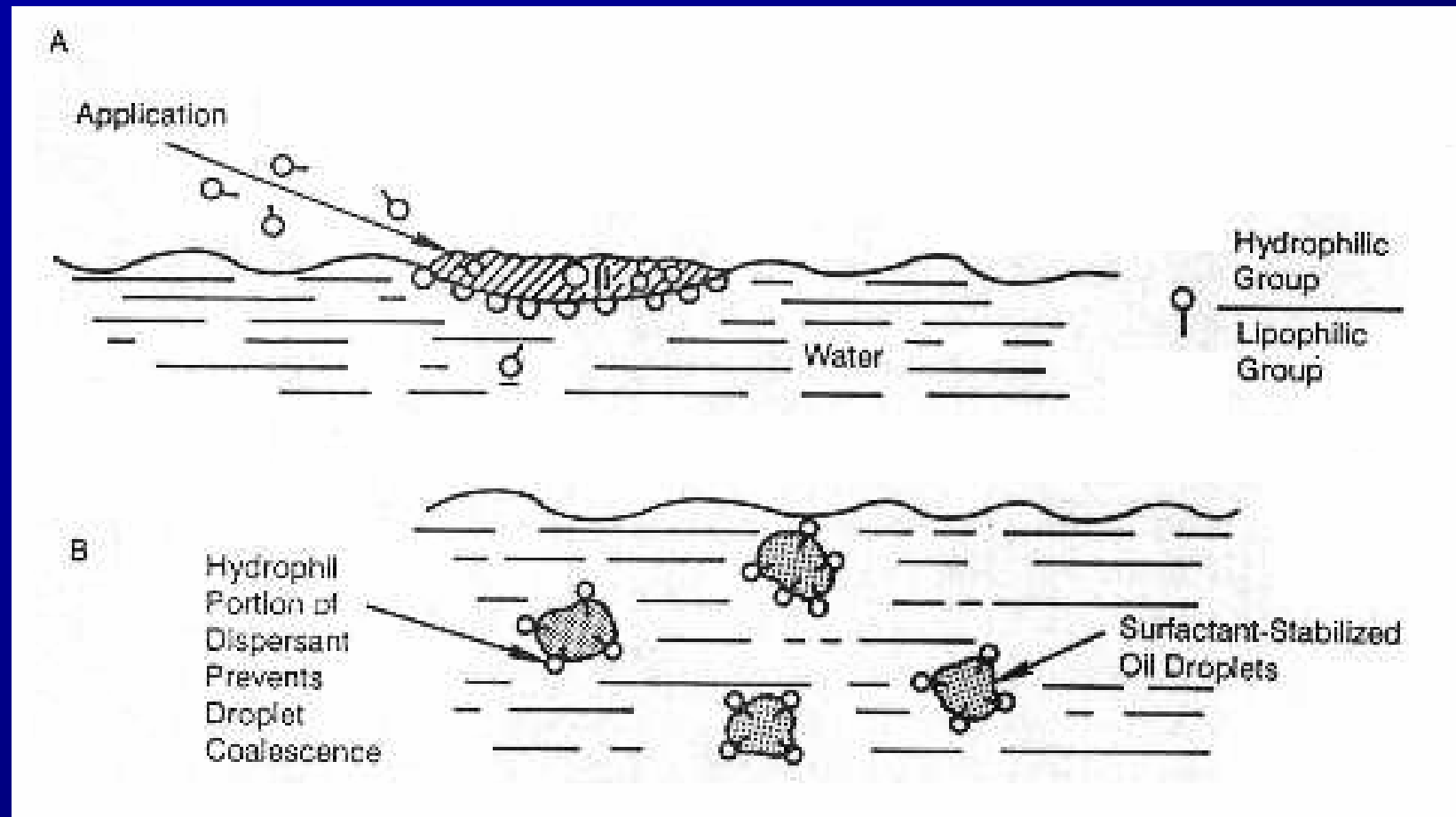
- Dispersants are surfactants dissolved in a solvent. Surfactants reduce the interfacial tension between water and oil, permitting the oil to break into tiny droplets with less energy required.
- Dispersants enhance a natural process.
- The ultimate fate of oil spilled in the marine environment is biodegradation. Dispersion enhances the rate of natural biodegradation by significantly increasing the surface-area-to-volume ratio of the spilled oil.

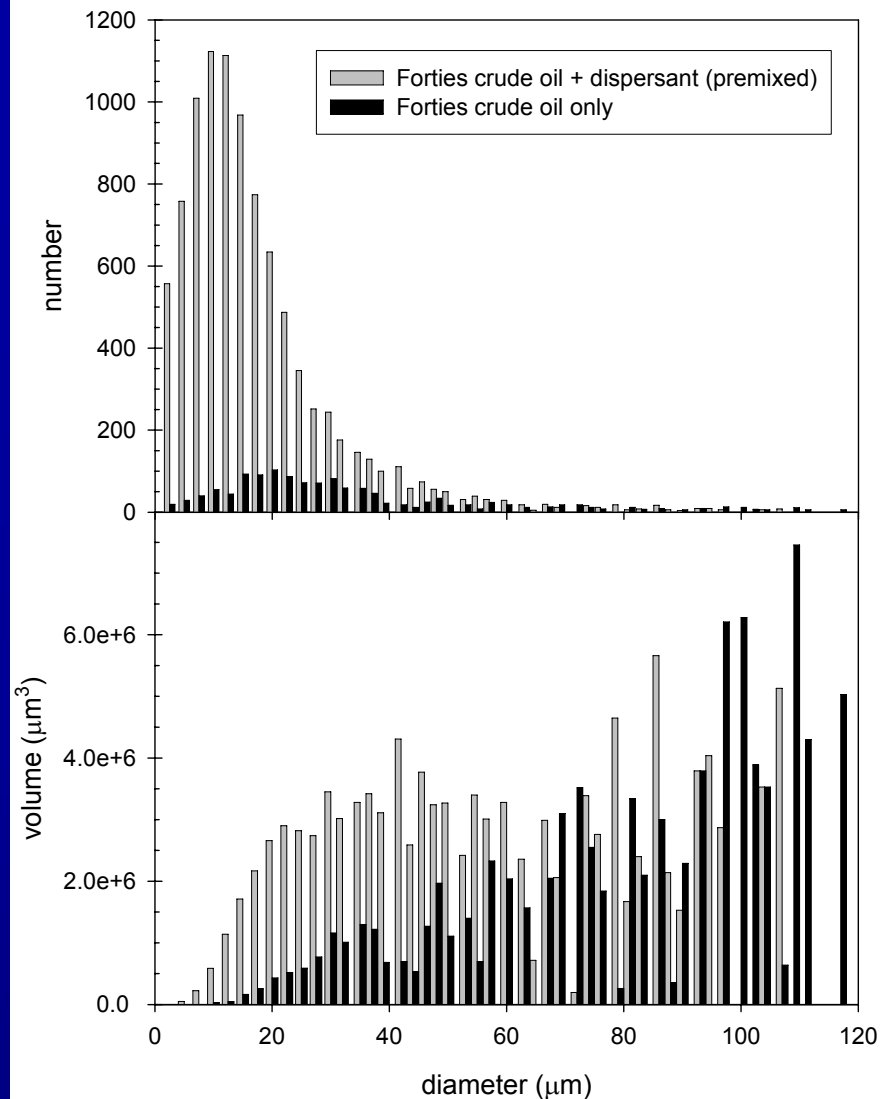


# Orientation of Surfactants at Oil-Water Interface (from NRC 2005)

# Mechanism of Chemical Dispersion

(from NRC 1989)





Oil droplet size distribution (in  $\mu\text{m}$ ) of premixed Forties crude oil and Slickgone NS measured at sea using a Phase Doppler Particle Analyzer (from Lunel 1995b and NRC 2005).



# Dispersant Use in California

## PAST:

- Quick-approval process (RRT)
- Hesitation to use dispersants
- Concerns about effectiveness and impacts
- Limited equipment and supplies



# Dispersant Use in California

## NOW:

- Pre-approval zones
- Quick-approval zones (through RRT)
- California Dispersant Plan
- Equipment & supplies
- Education
- Acceptance of dispersants
- SMART



Future use of dispersants in CA likely

# Scientific Monitoring of Advanced Response Technologies (SMART): A Tiered Program

- **Tier I** - employs the simplest operation, visual monitoring.
- **Tier II** - combines visual monitoring with on-site fluorometry at a single depth with water-samples collected for later analysis.
- **Tier III** - advanced Tier II.

# SMART

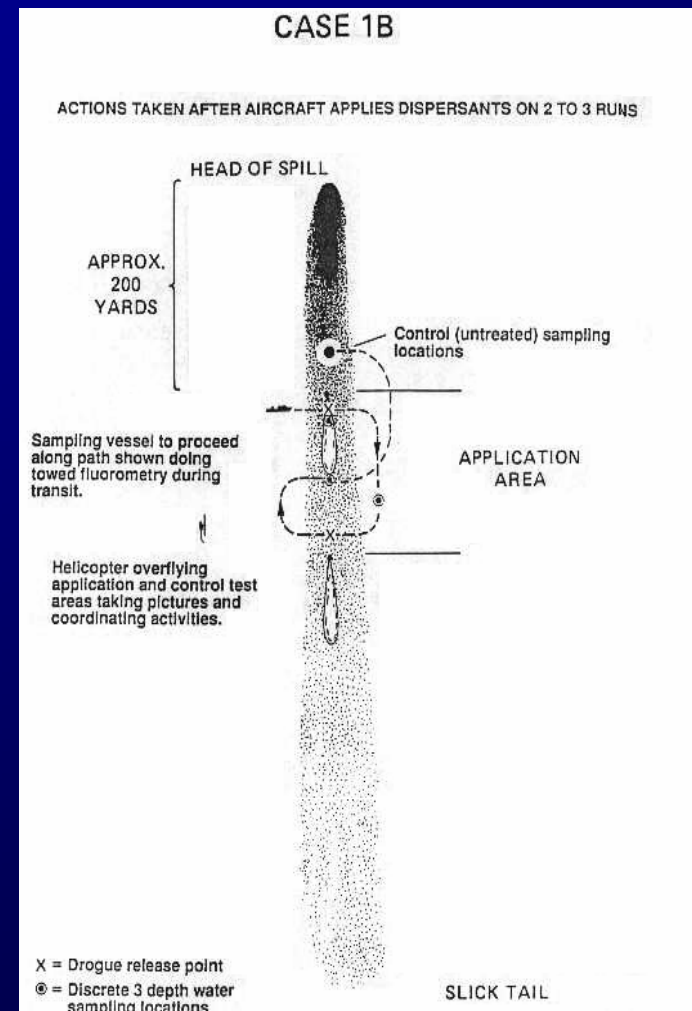
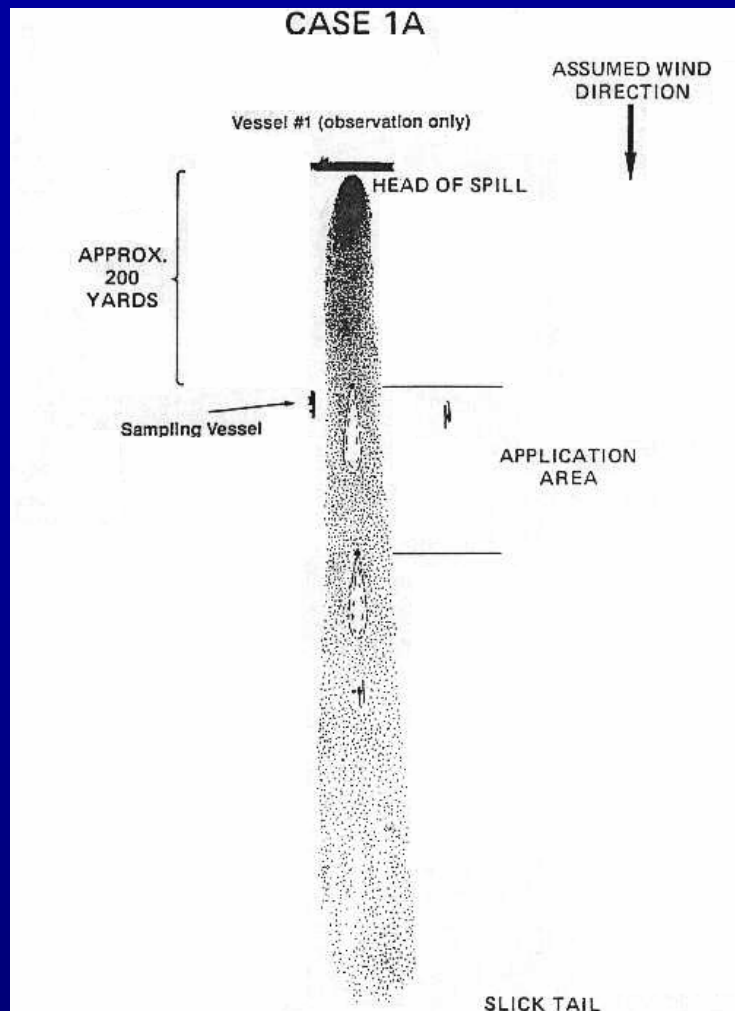
## Special Monitoring of Applied Response Technologies (SMART)

- SMART measures effectiveness of dispersant application to assist Incident Commander
- SMART does not measure effects of dispersed oil on wildlife or exposed organisms

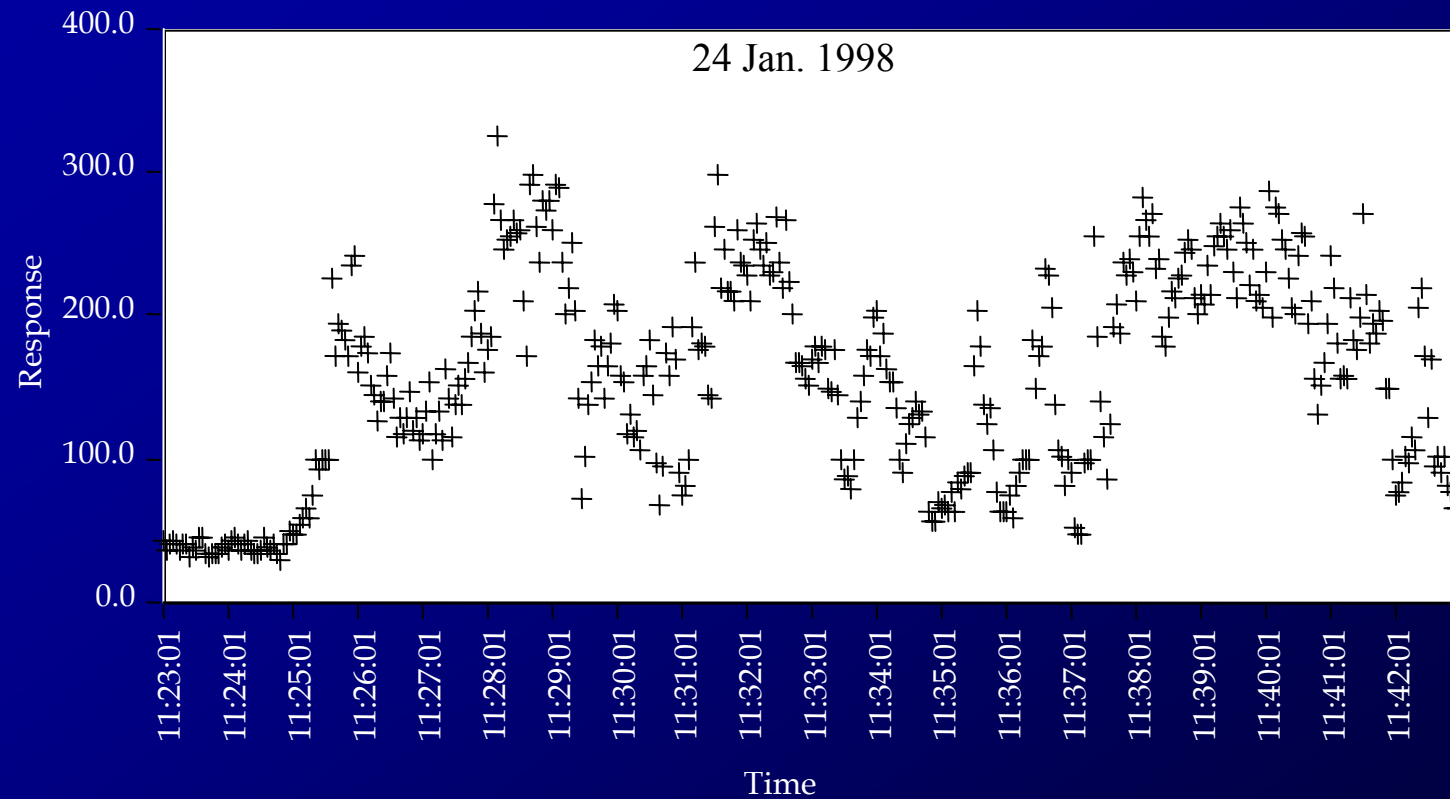




# Approaches to Effectiveness Monitoring (from Payne et al. 1991)

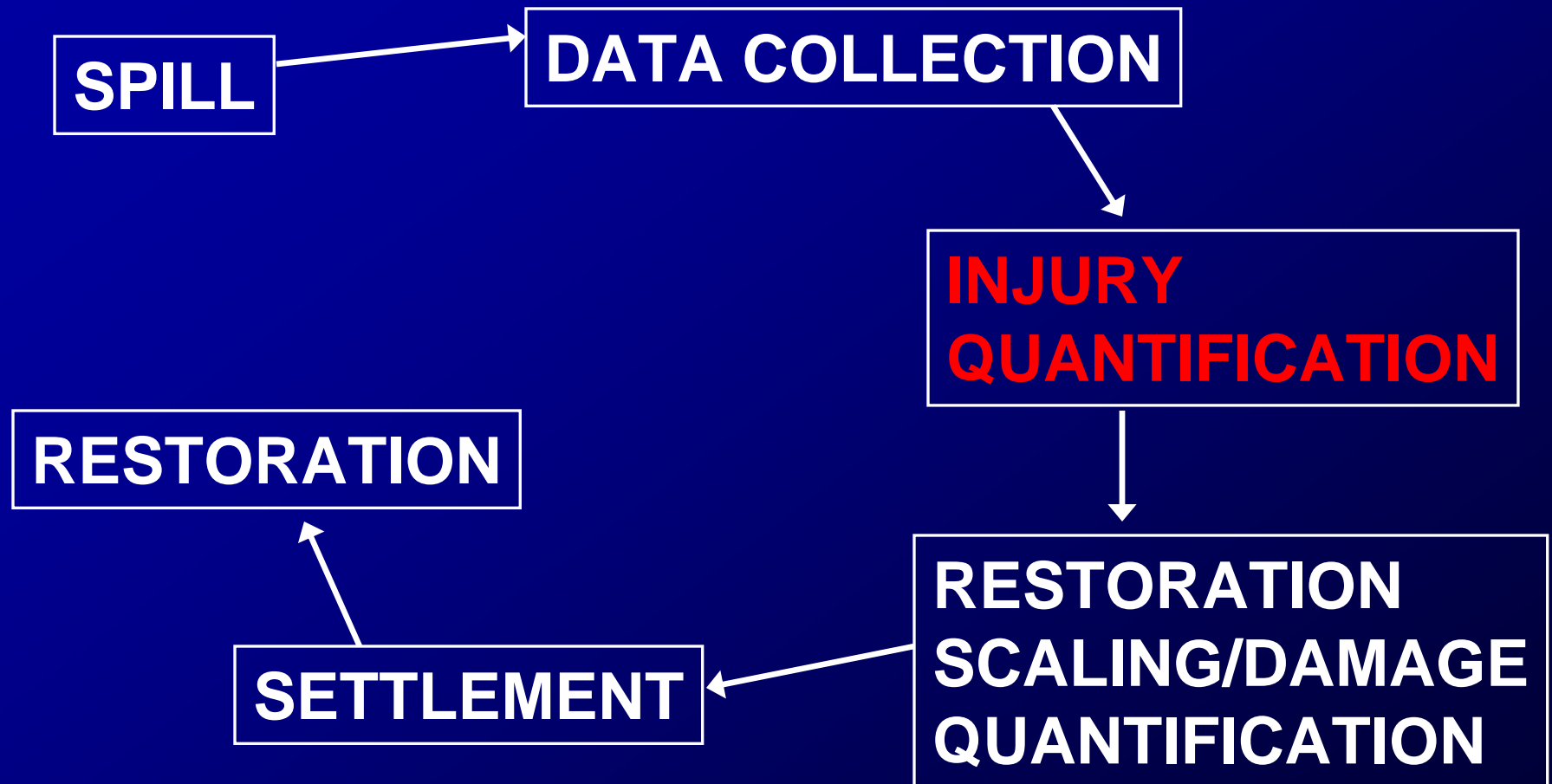


# Tier II SMART Data: HIPS



Note the “patchy” nature of a dispersed oil plume.

# NRDA Process:



# California Dispersed Oil Monitoring Plan (DOMP)

## Principle investigators:

- R. Lewis
- Dr. W. Nordhausen
- Dr. D. French McCay
- Dr. J. Payne

## Collaborators:

- Y. Addassi
- M. Sowby
- Dr. J. Cubit
- H. Parker Hall





# California Dispersed Oil Monitoring Plan (DOMP)

## Objectives

- Develop a plan to quantify and evaluate impacts to aquatic organisms after a spill where dispersants are used
- Provide data for NRDA
- Evaluate effects for decision making for future spills

# Dispersed Oil Monitoring Plan

## HOW ?

- Quantity (size of dispersed oil plume)
- Components (dissolved-phase & oil droplets)
- Concentration
- Duration
- Environmental impact
- Documentation

→ Sampling plan

# Dispersed Oil Monitoring Plan

## Our approach...

- Computer simulation using ASA's **Spill Impact Model Application Package (SIMAP)** combined with **Biological Exposure Model**
- Prepare sampling plan based on simulation results
- Prepare standby equipment & retain contractors



# SIMAP

## 3D Transport and Fates Model

- Surface slicks
- Subsurface droplets
- Water column aromatics: dissolved and oil phase
- Sediment aromatics: dissolved and adsorbed
- Sediment total hydrocarbons
- Response module
- Shoreline deposition and removal
- Mass balance



# SIMAP Modeling Matrix

- Hypothetical spills in open water.
- Oil type: Light Arabian crude.
- Spill volume: maximum volume of oil dispersed by a single sortie of a C-130 (5,000 gallons dispersant at 1:20 DOR = 100,000 gallons treated). An assumed 80% efficiency yields 80,000 gal of dispersed oil.
- Oil thickness: median value for dispersant application (100  $\mu\text{m}$ ).
- 3 dispersant application scenarios: none; after weathering 8 hrs, after weathering 16 hrs.
- 2 wind speeds and associated turbulence conditions: 5 kts, 15 kts.
- Restricted to surface mixed layer: 10m or 20m.
- Background currents: none, 0.25 kts downwind, 0.25 kts upwind.

## **Scenario**

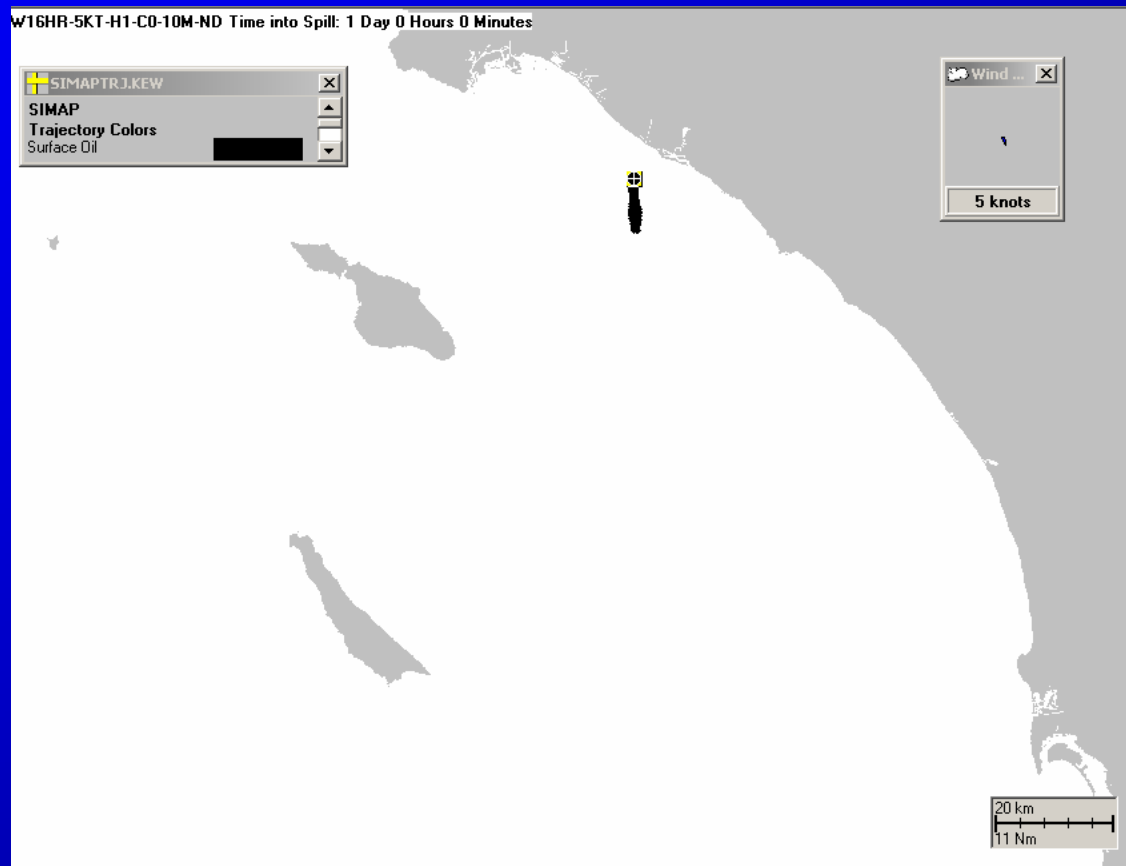
**Pre-Weathering for 16 hrs before potential treatment**

**Wind from NNW 5 kts;  
Currents: 0 kt;**

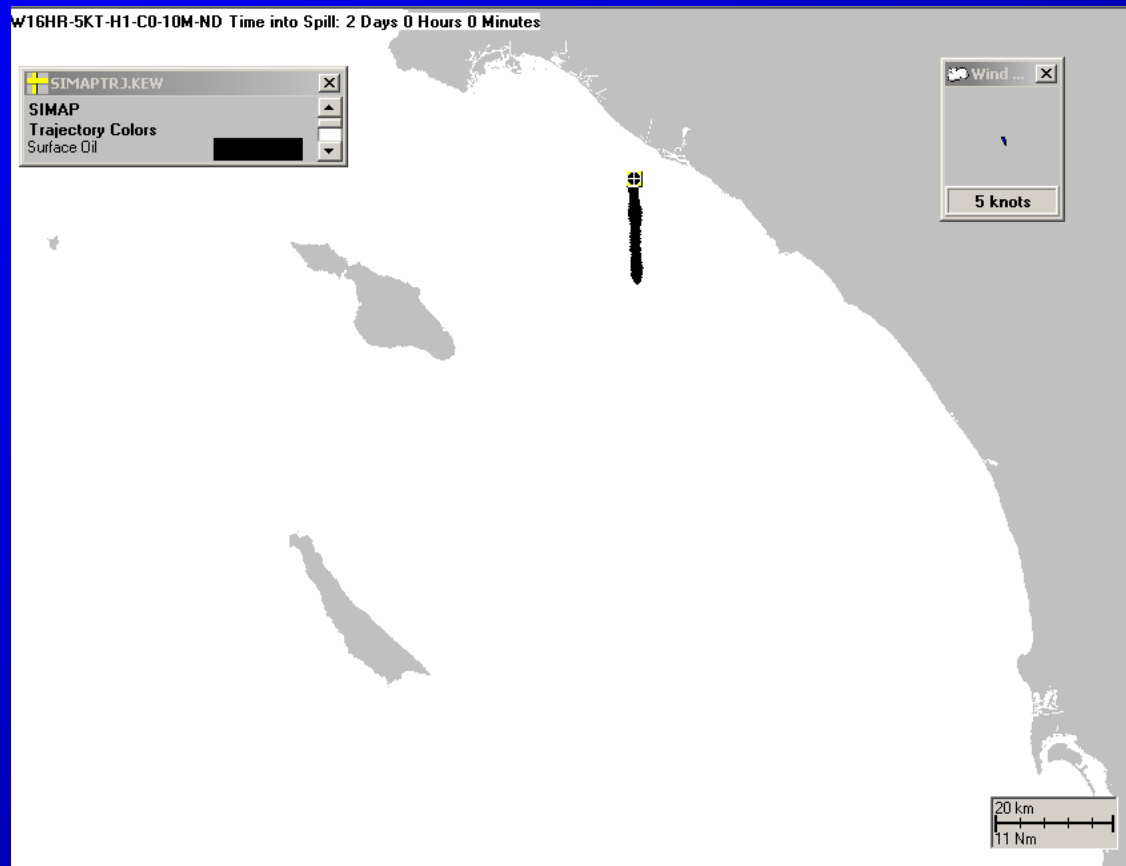
**Dispersant: none**

**Turbulent Mixing to 10m deep in Surface Mixed Layer**

**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m  
deep;  
Trajectory: 24 hrs after potential treatment**

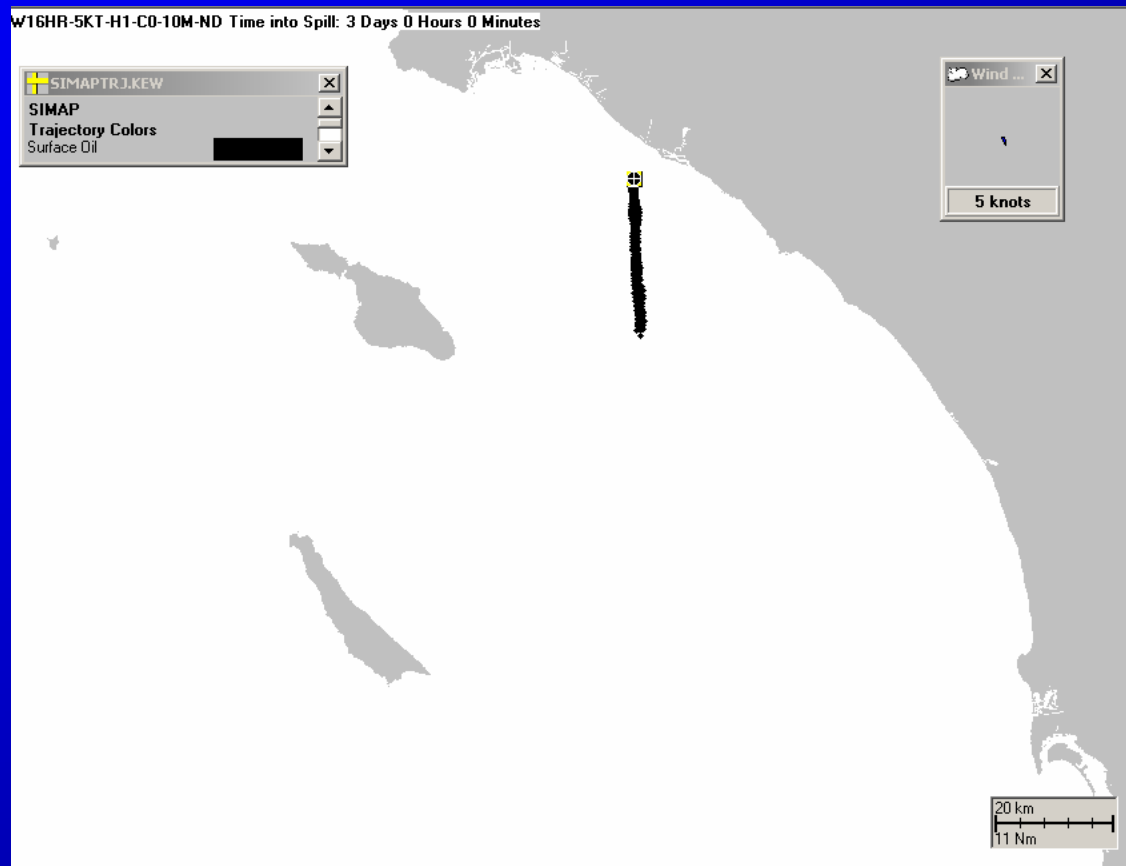


**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m  
deep;  
Trajectory: 48 hrs after potential treatment**

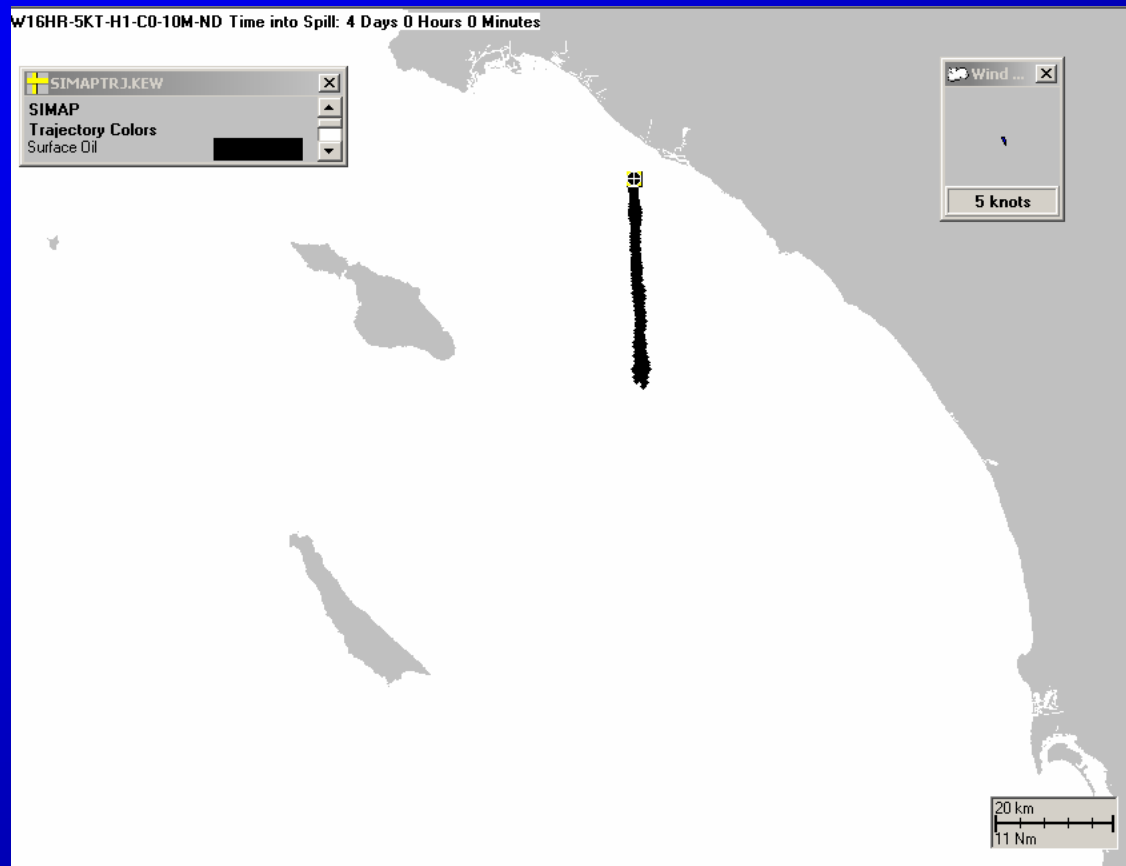




**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m  
deep;  
Trajectory: 72 hrs after potential treatment**



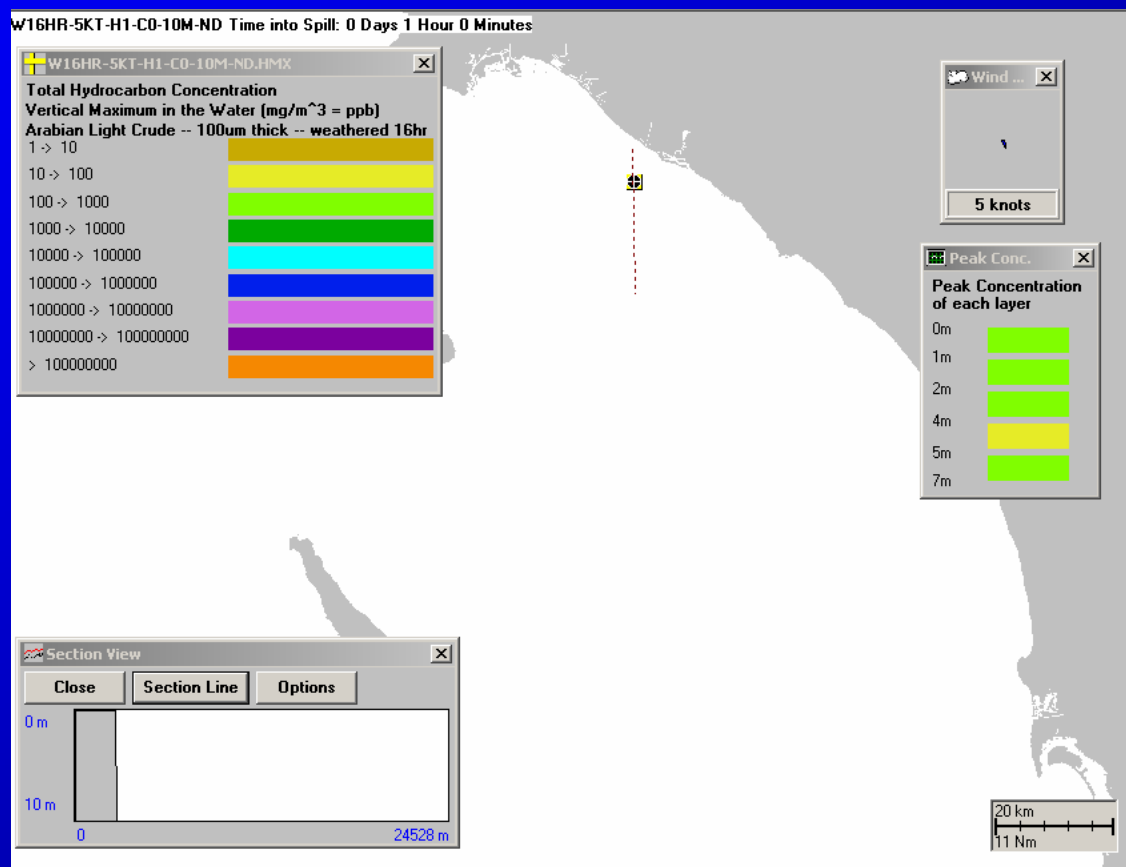
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m  
deep;  
Trajectory: 96 hrs after potential treatment**



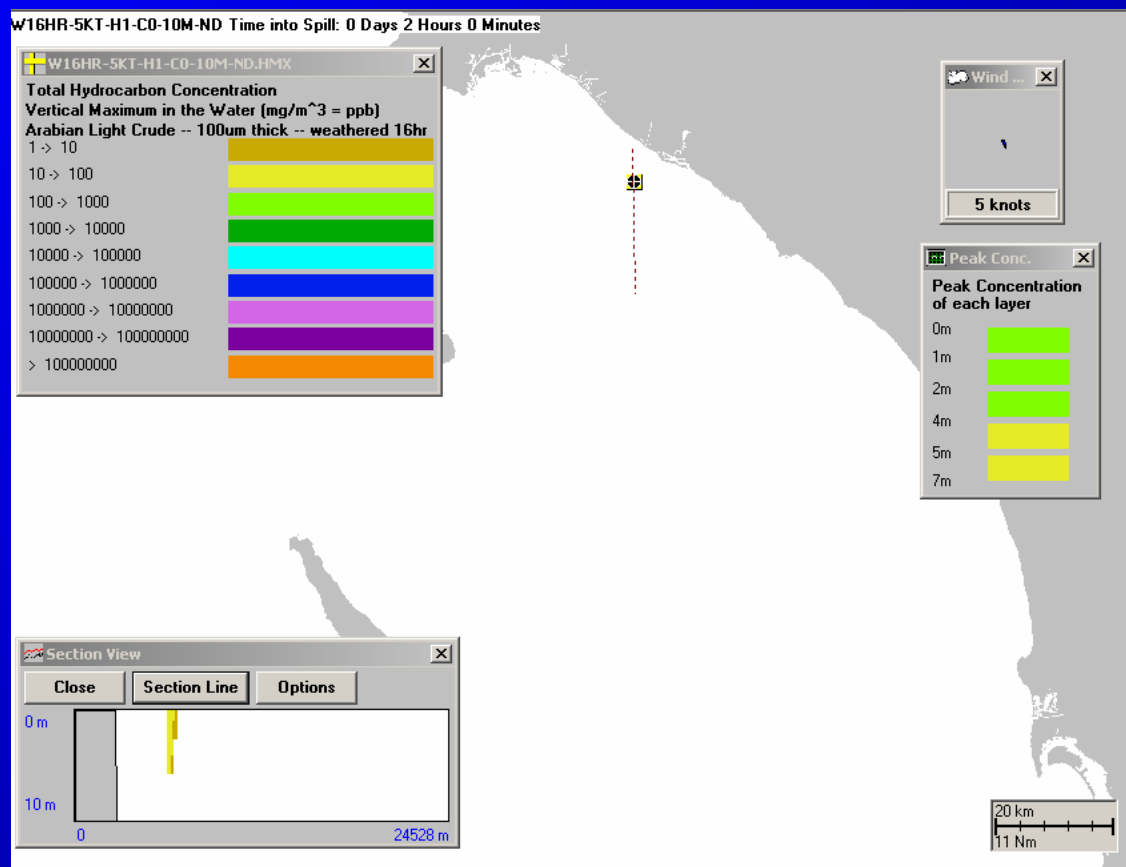
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m  
deep;**

**Subsurface Oil Droplet Concentrations**

**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 1 hr after potential treatment**

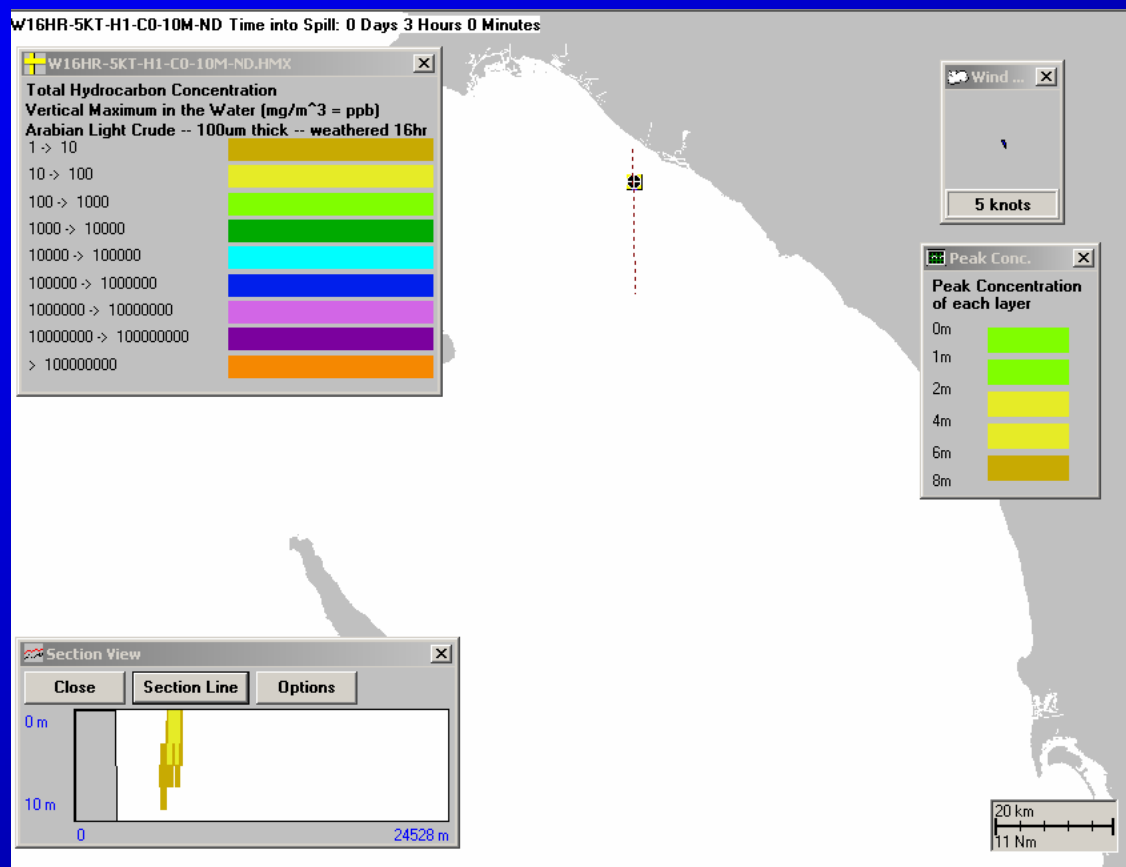


**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 2 hrs after potential treatment**

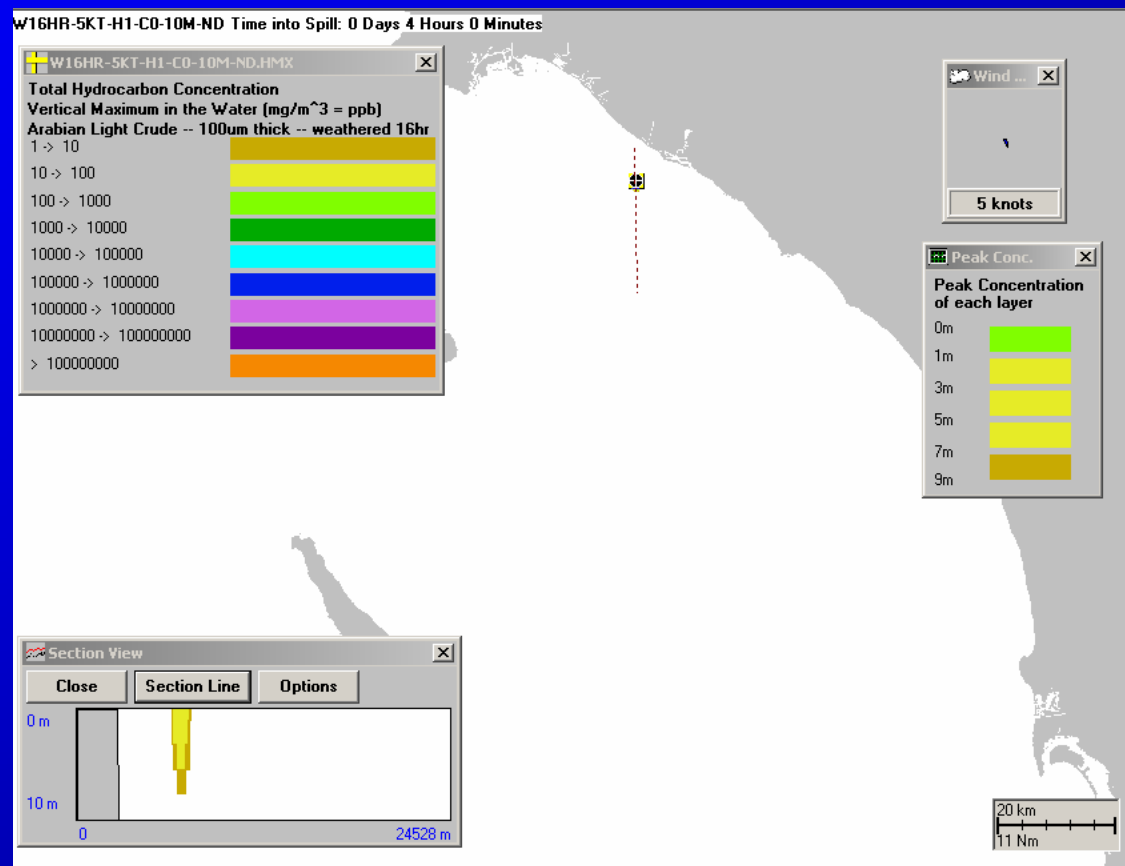




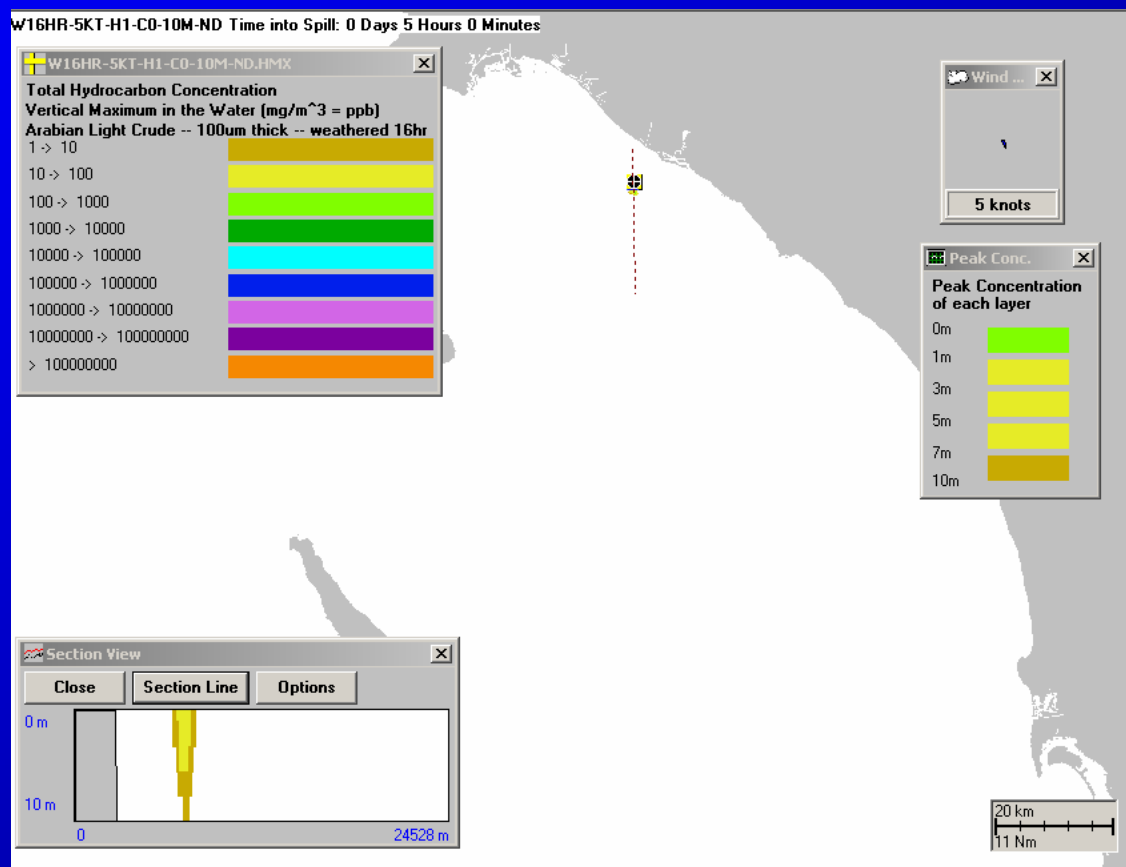
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 3 hrs after potential treatment**



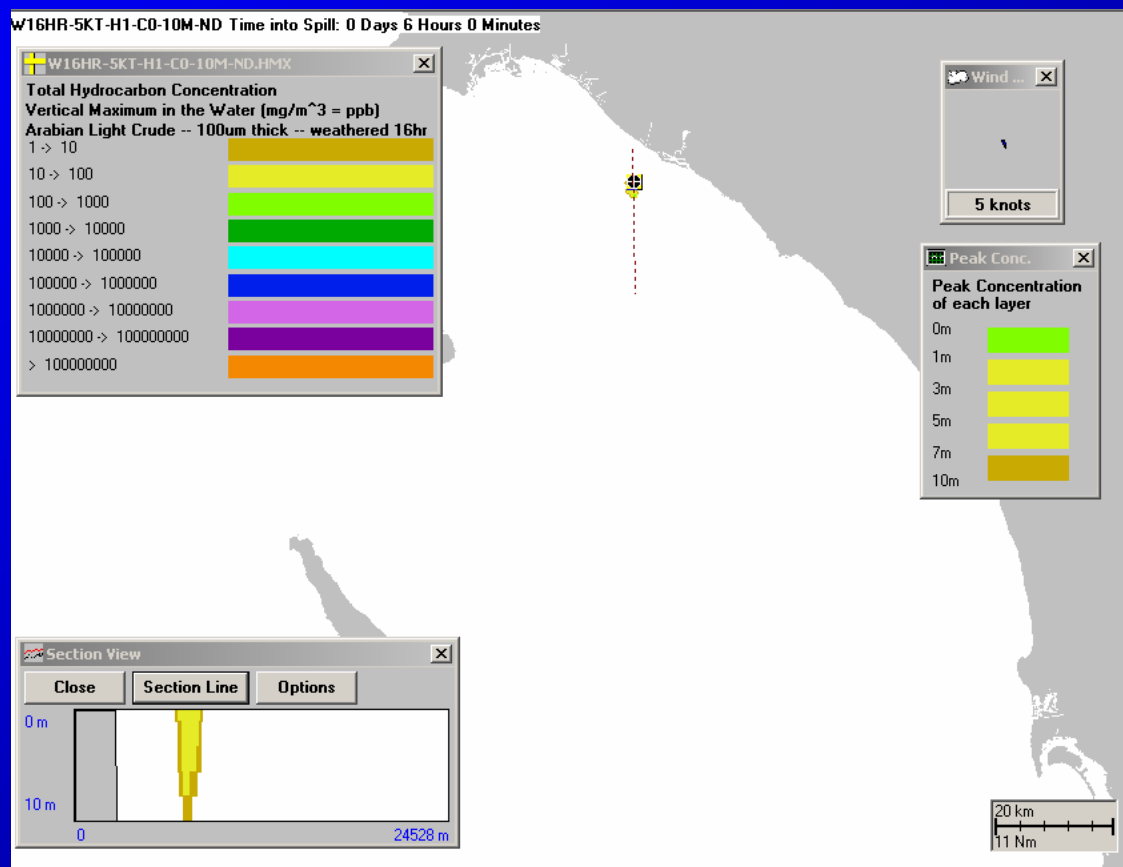
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 4 hrs after potential treatment**



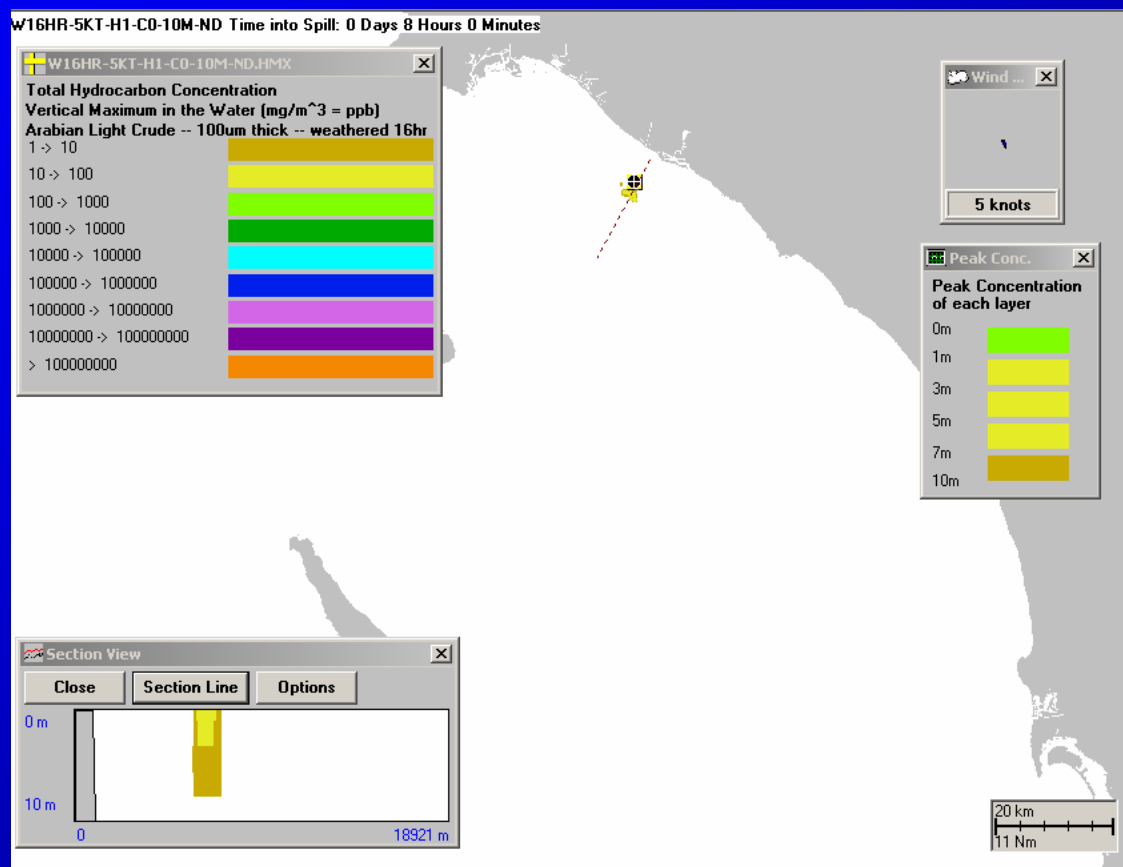
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 5 hrs after potential treatment**



**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 6 hrs after potential treatment**

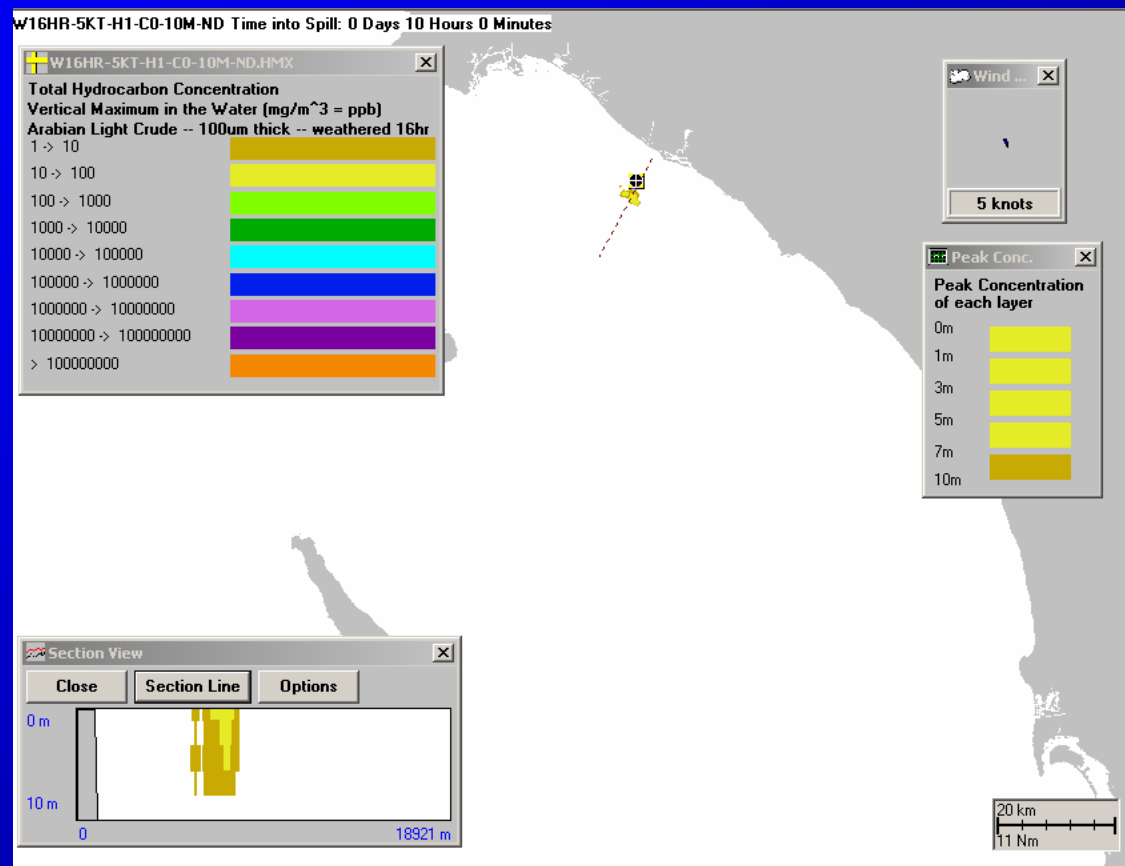


**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 8 hrs after potential treatment**

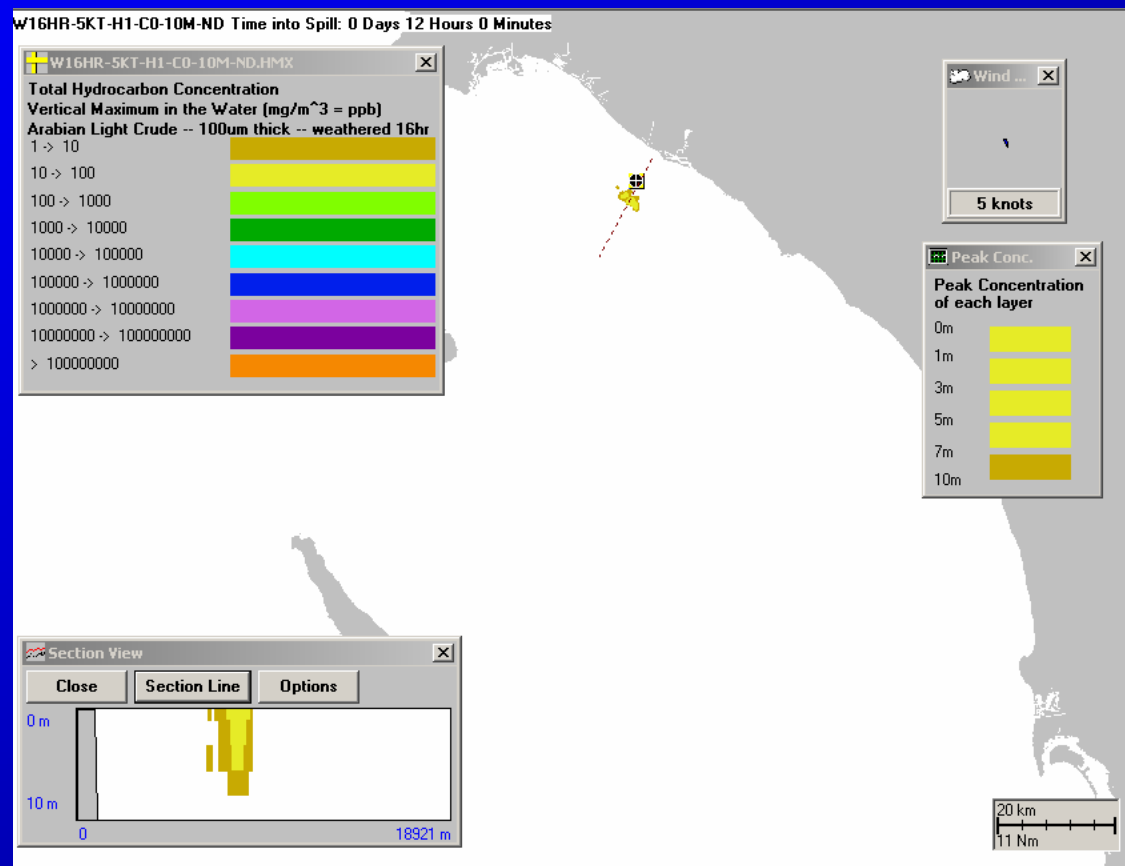




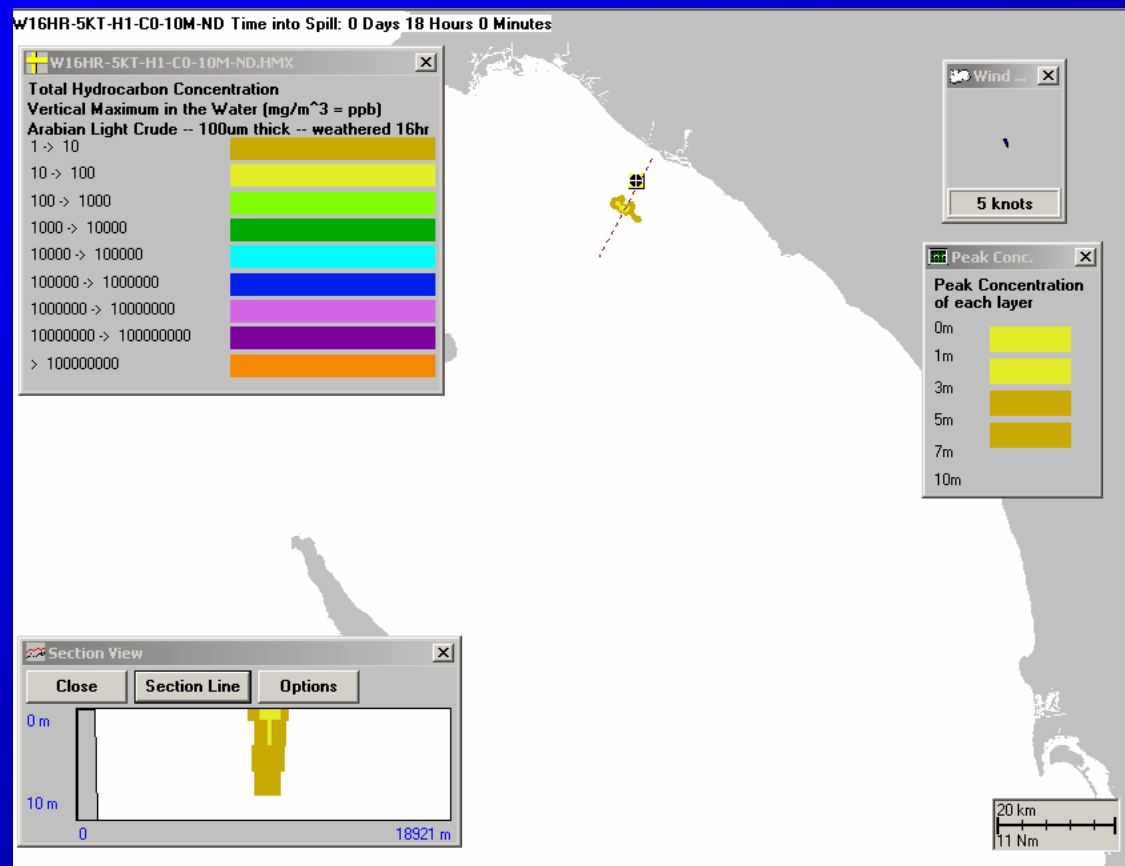
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Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 10 hrs after potential treatment**



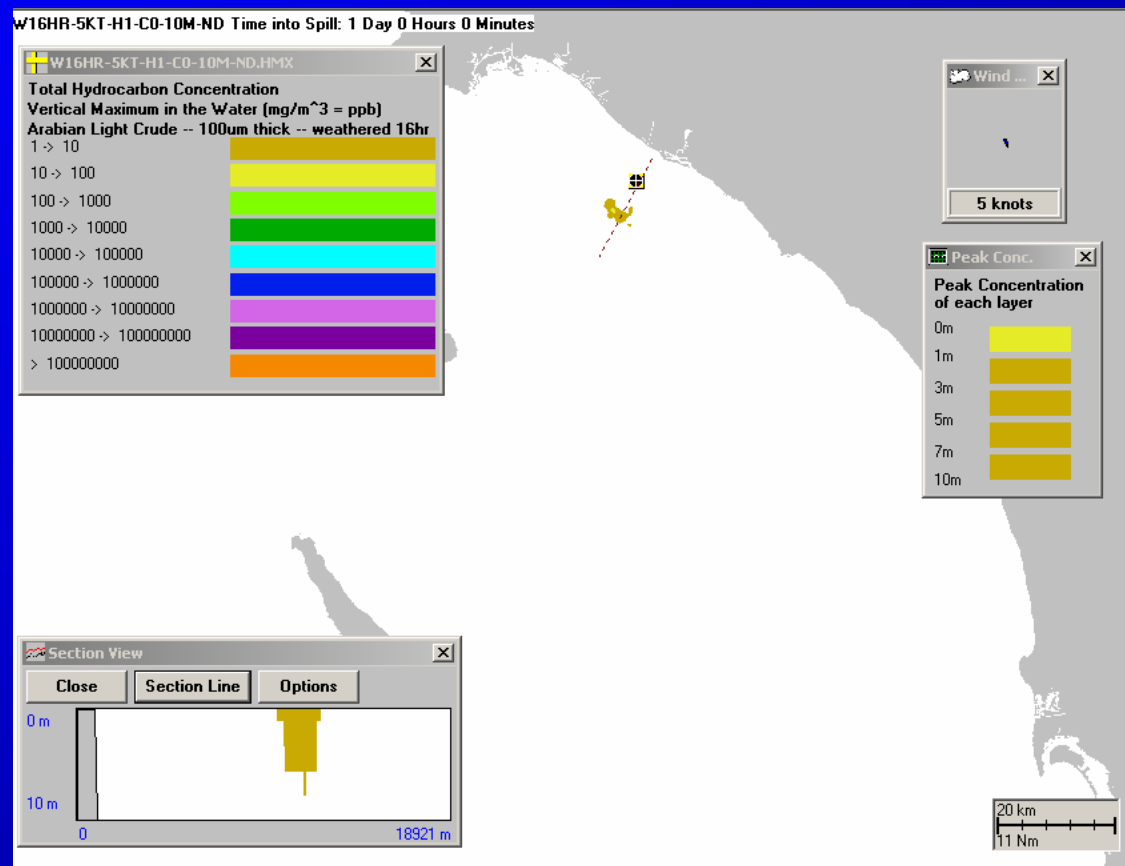
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 12 hrs after potential treatment**



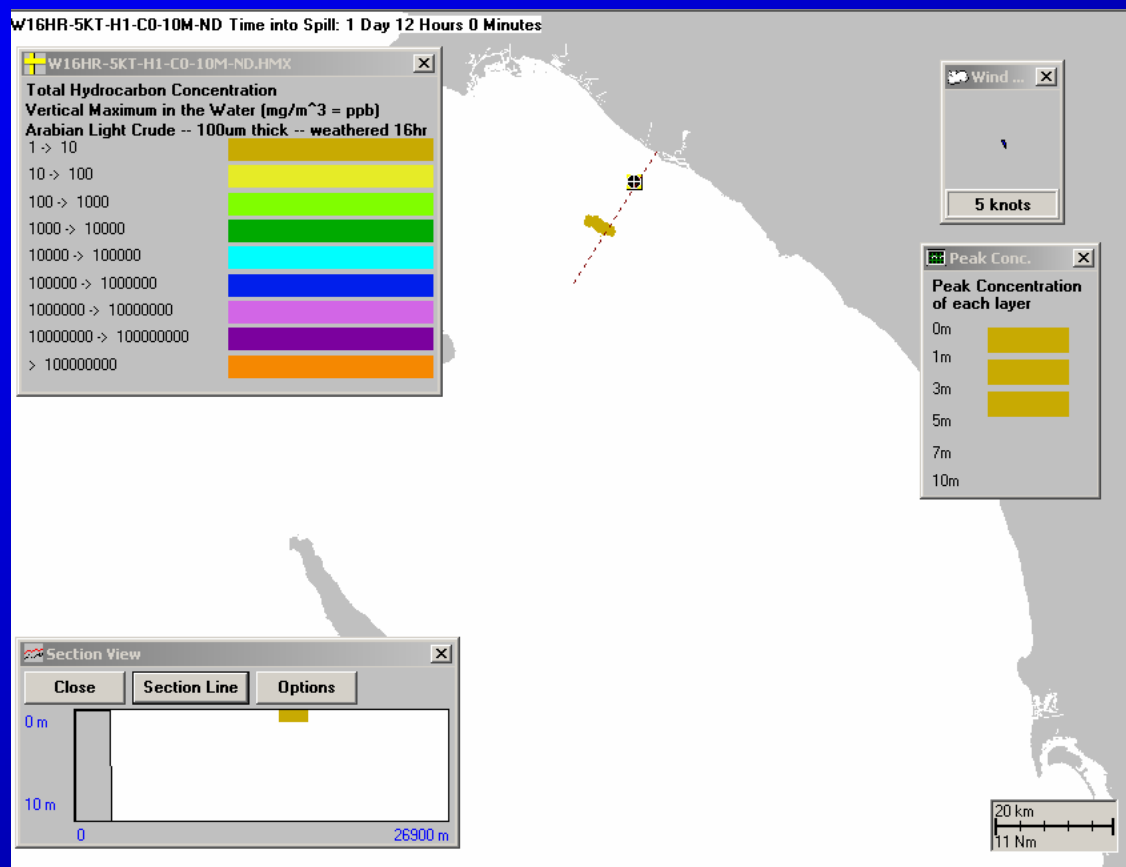
**Wind from NNW 5 kts; Currents: 0 kt;**  
**Dispersant: none; Turbulent mixing to 10m deep;**  
**Subsurface Oil Droplet Concentrations: 18 hrs after potential treatment**



**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 24 hrs after potential treatment**

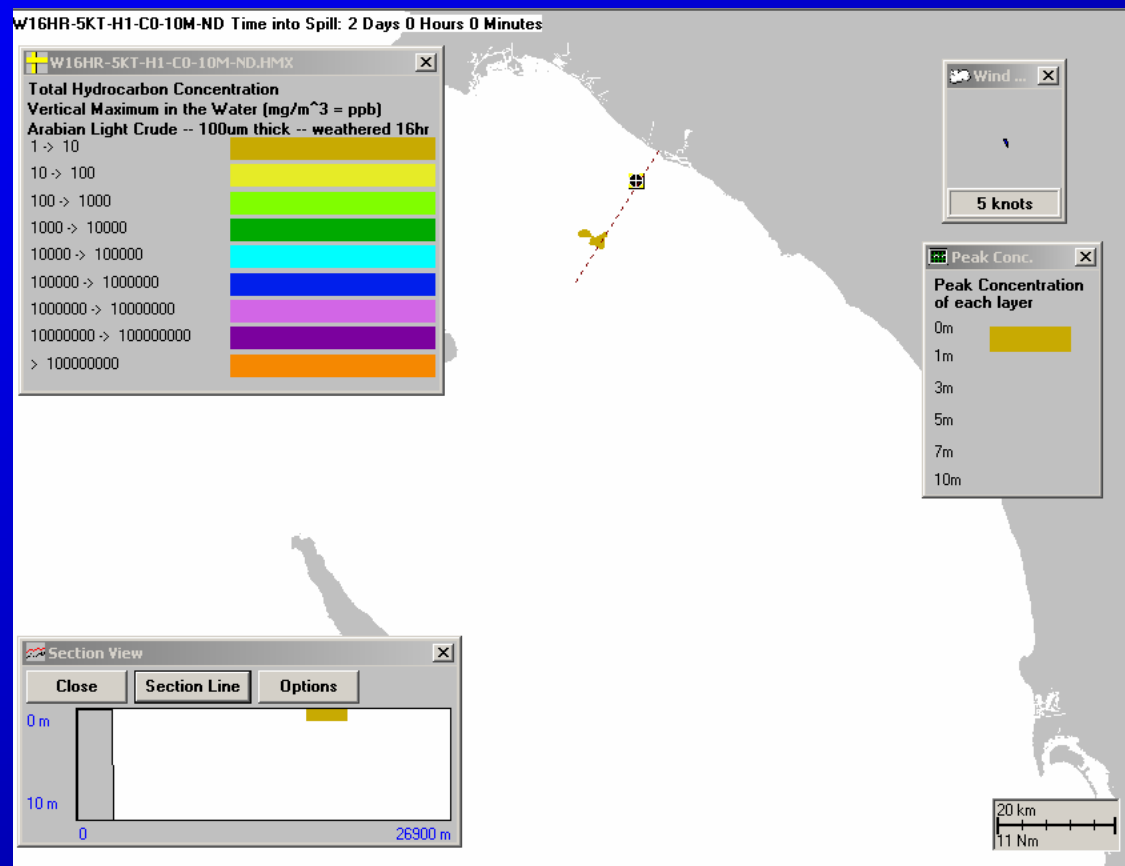


**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 36 hrs after potential treatment**

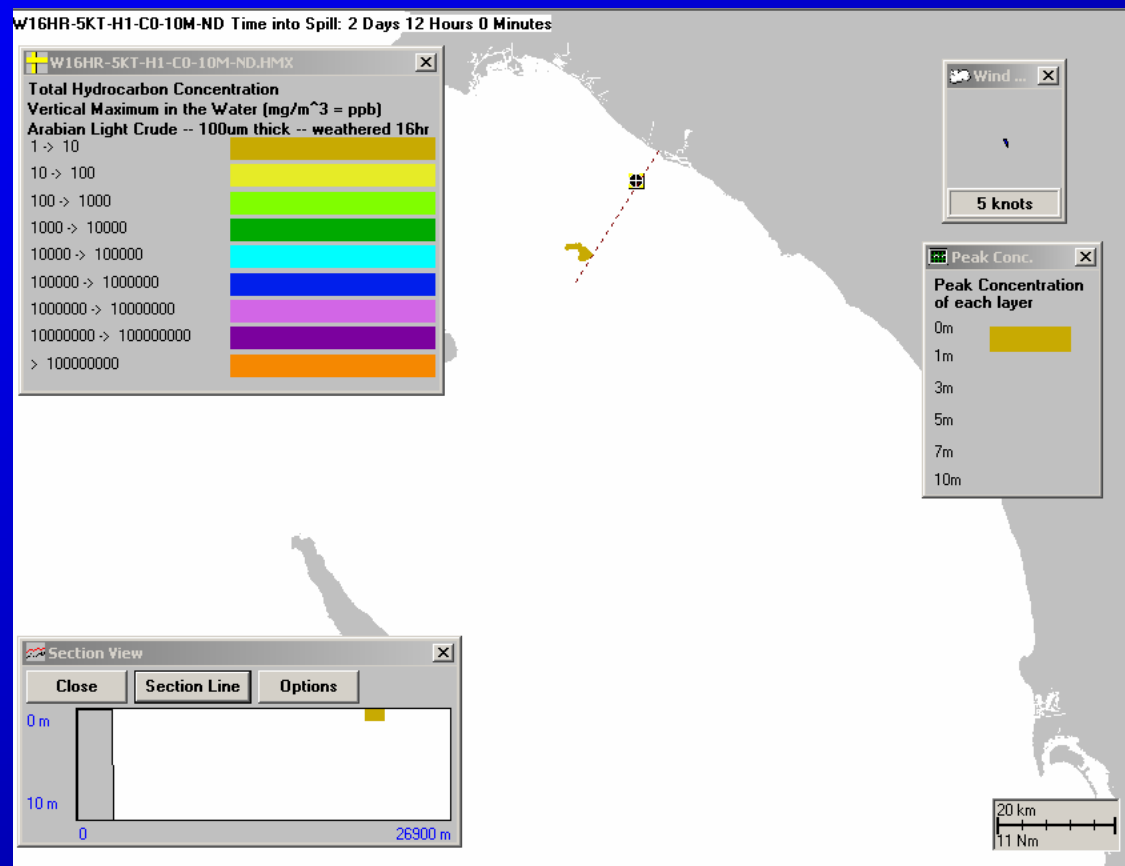




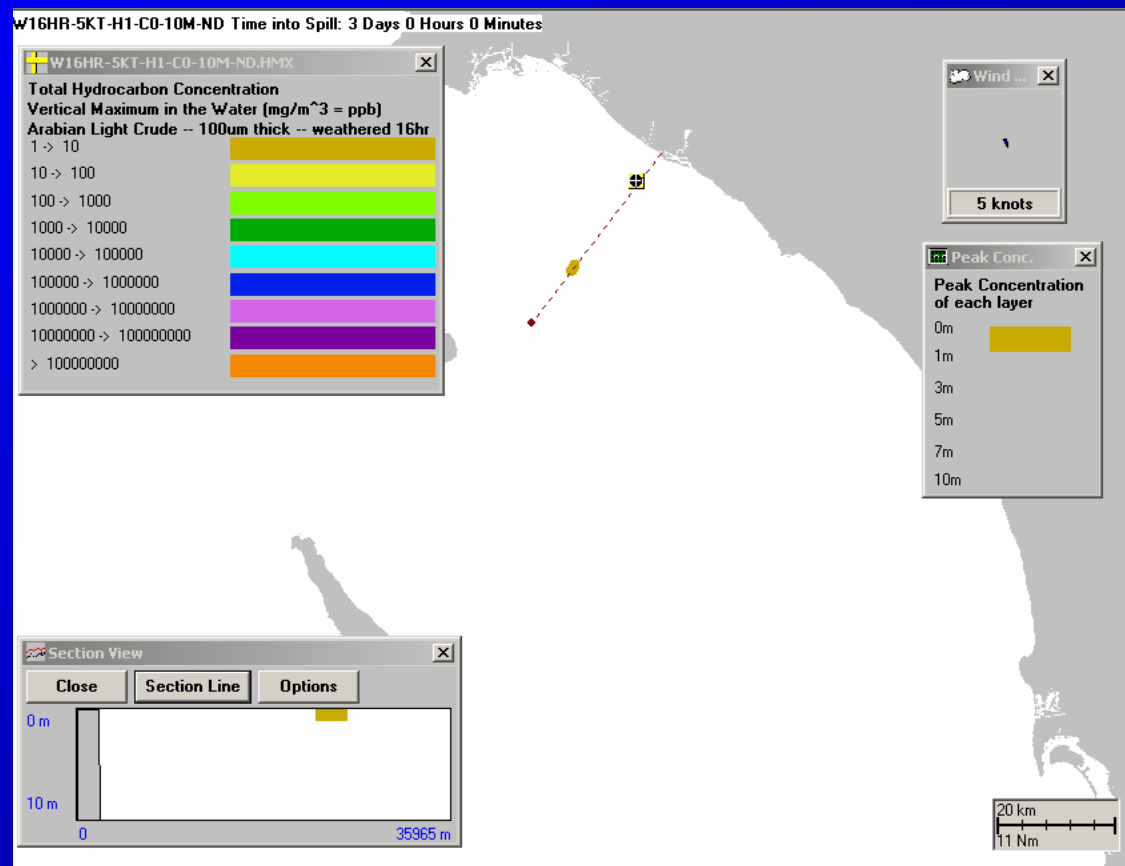
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 48 hrs after potential treatment**



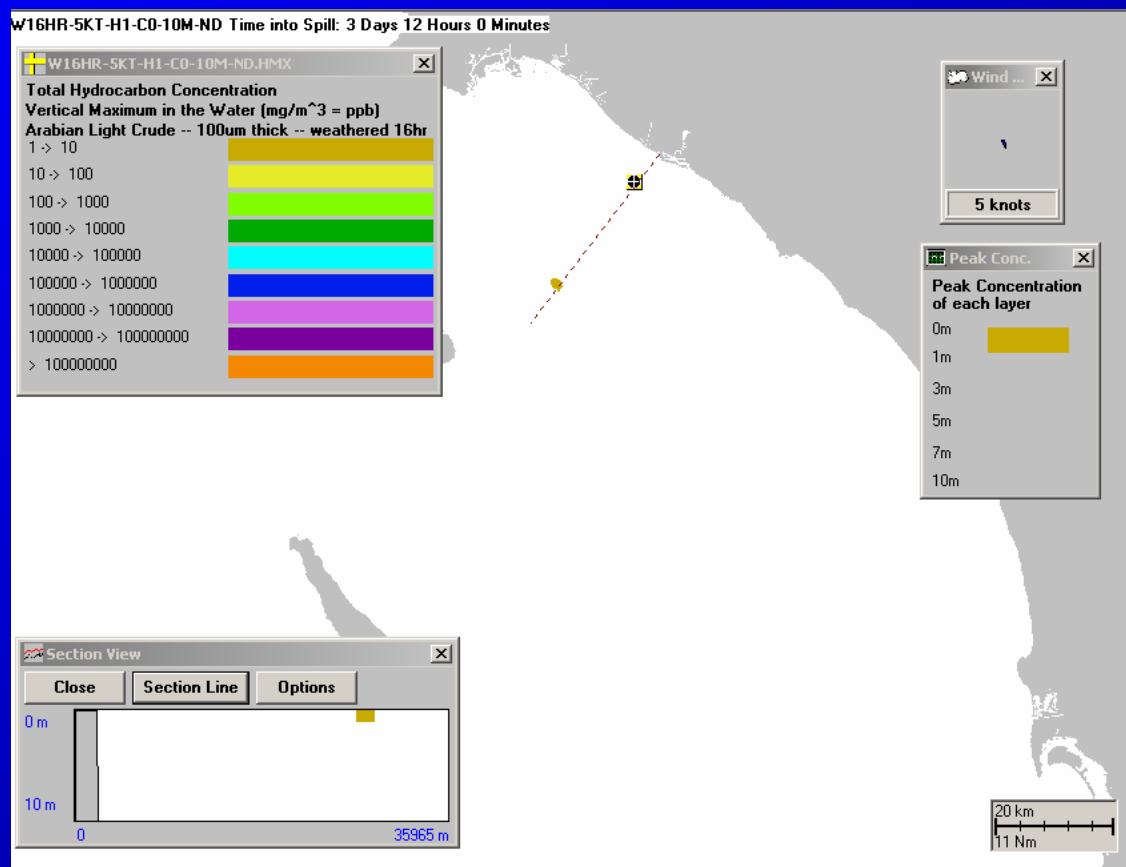
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 60 hrs after potential treatment**



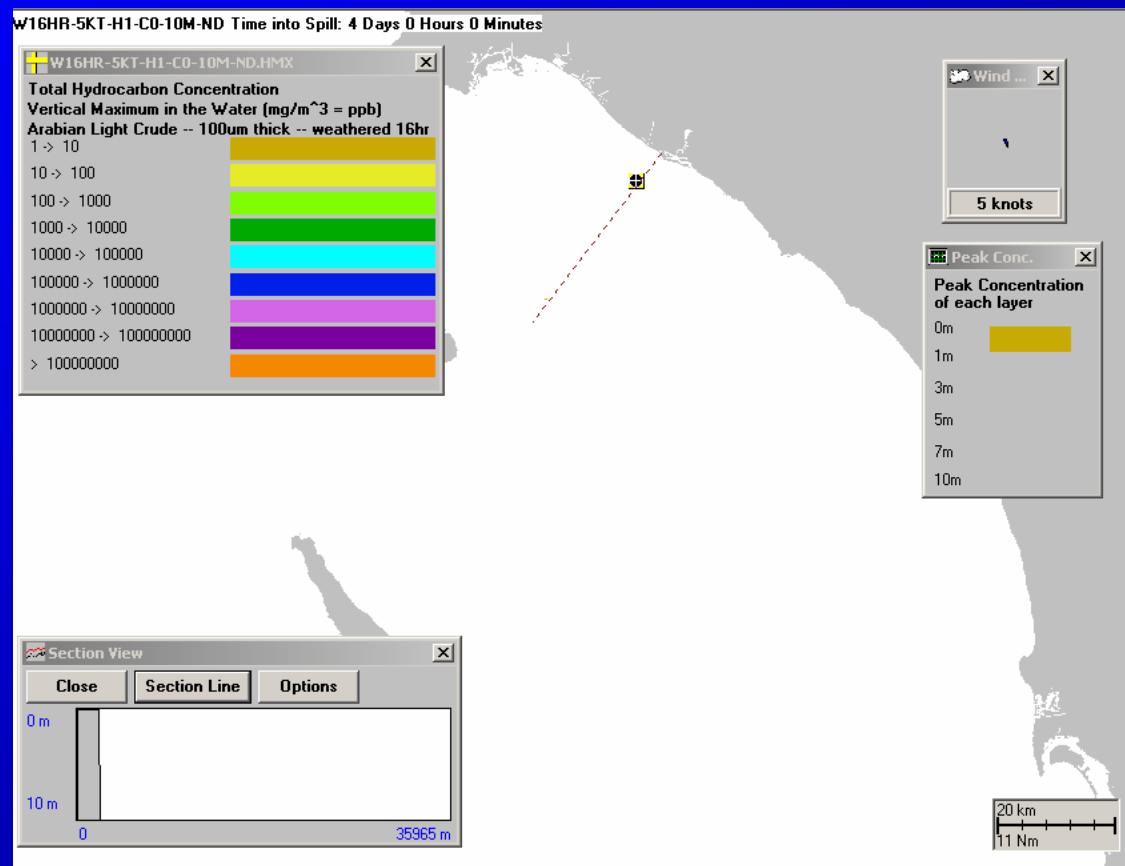
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 72 hrs after potential treatment**



**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 84 hrs after potential treatment**



**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 96 hrs after potential treatment**

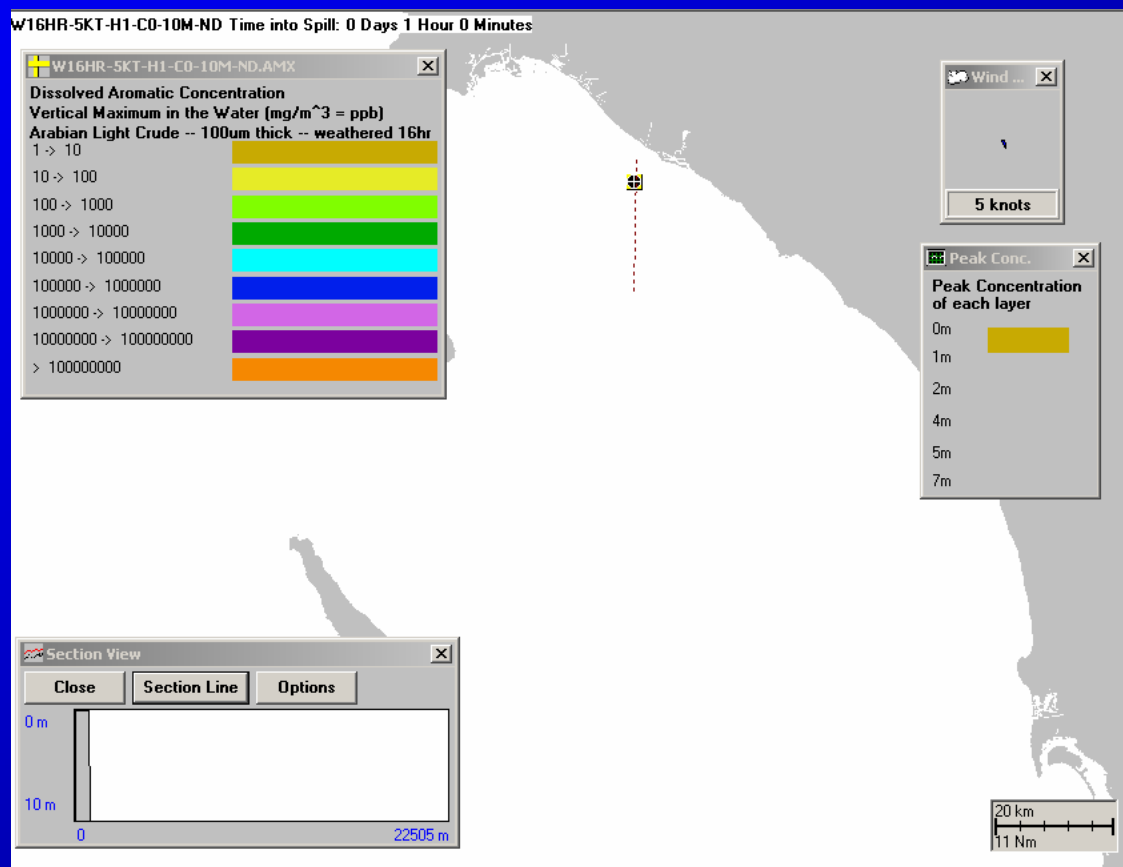


**Wind from NNW 5 kts; Currents: 0 kt;  
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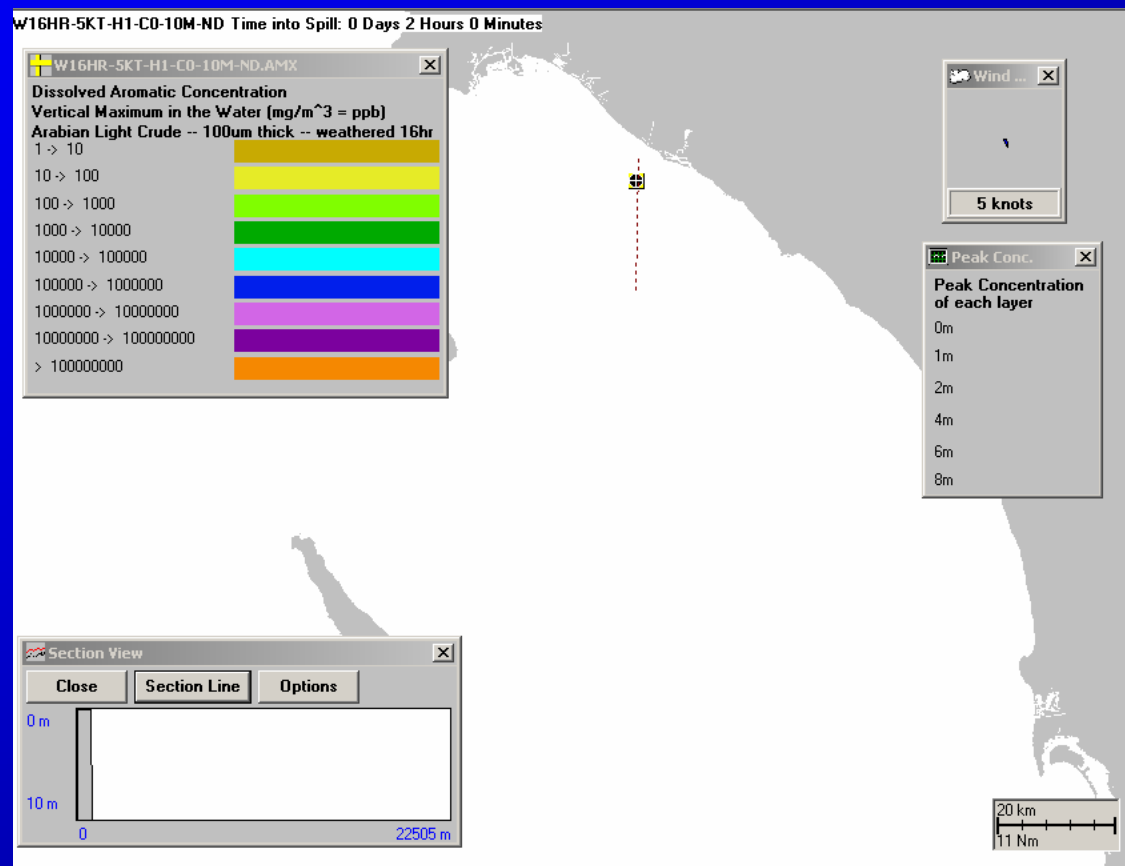
**Dissolved Aromatic Concentrations**



**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 1 hr after potential treatment**



**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: none; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 2 hrs after potential treatment**



**\*No dissolved aromatic conc. > 1ppb (averaged) in any grid cell after 2 hrs**

## **Scenario**

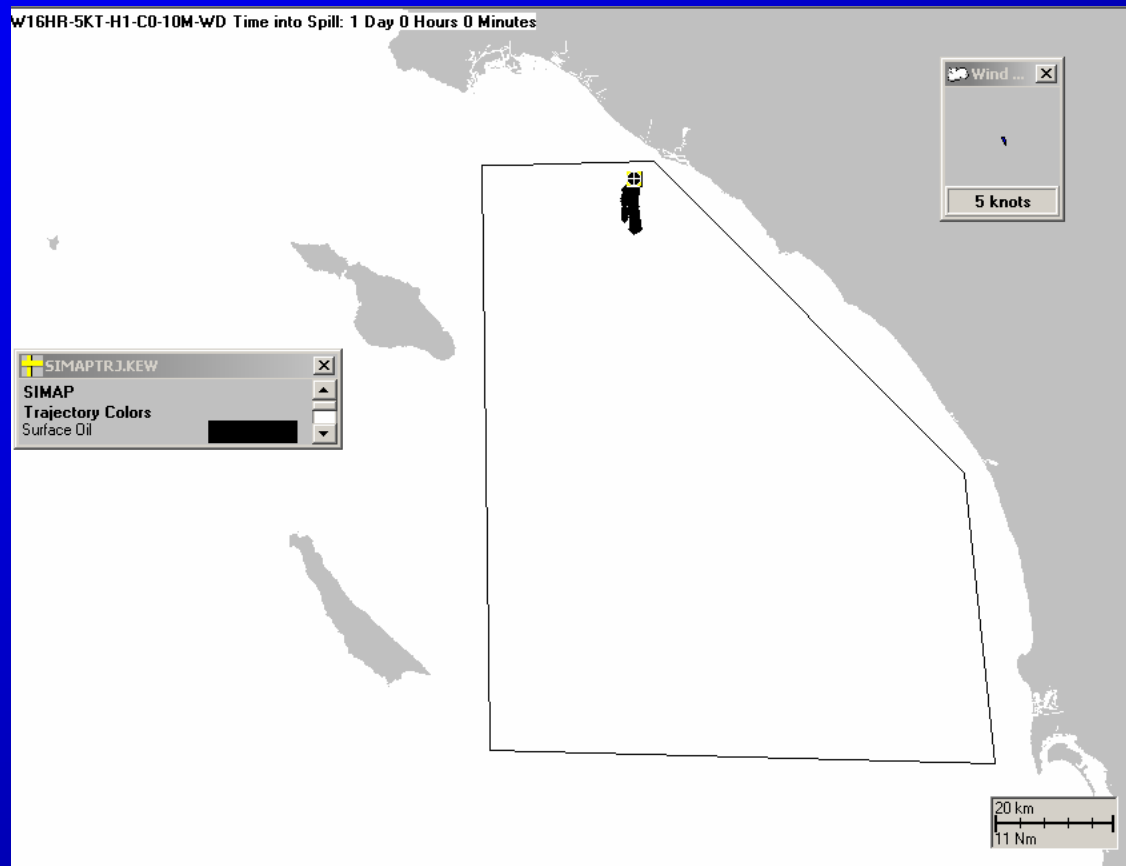
**Pre-Weathering for 16 hrs before dispersant treatment**

**Wind from NNW 5 kts;  
Currents: 0 kt;**

**Dispersant: at 16 hrs after Spill**

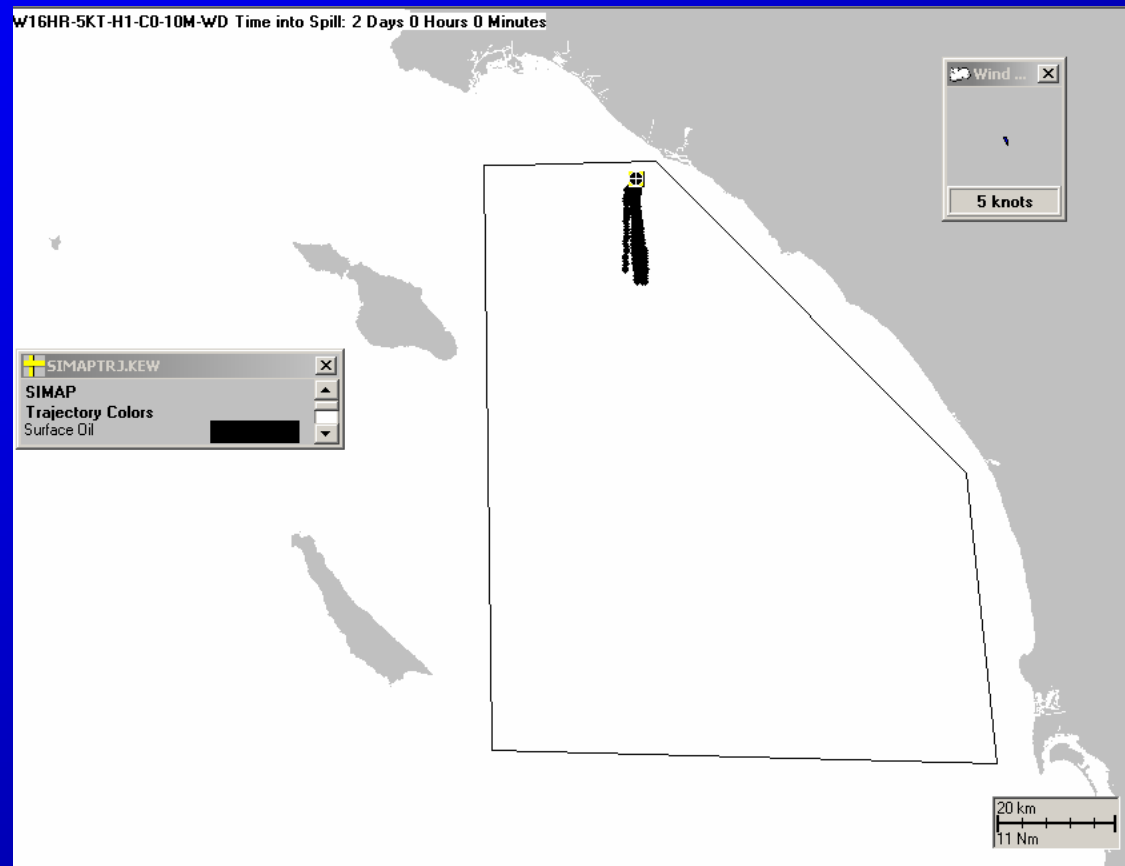
**Turbulent Mixing to 10m deep in Surface Mixed Layer**

**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m  
deep;  
Trajectory: 24 hrs after dispersant application**

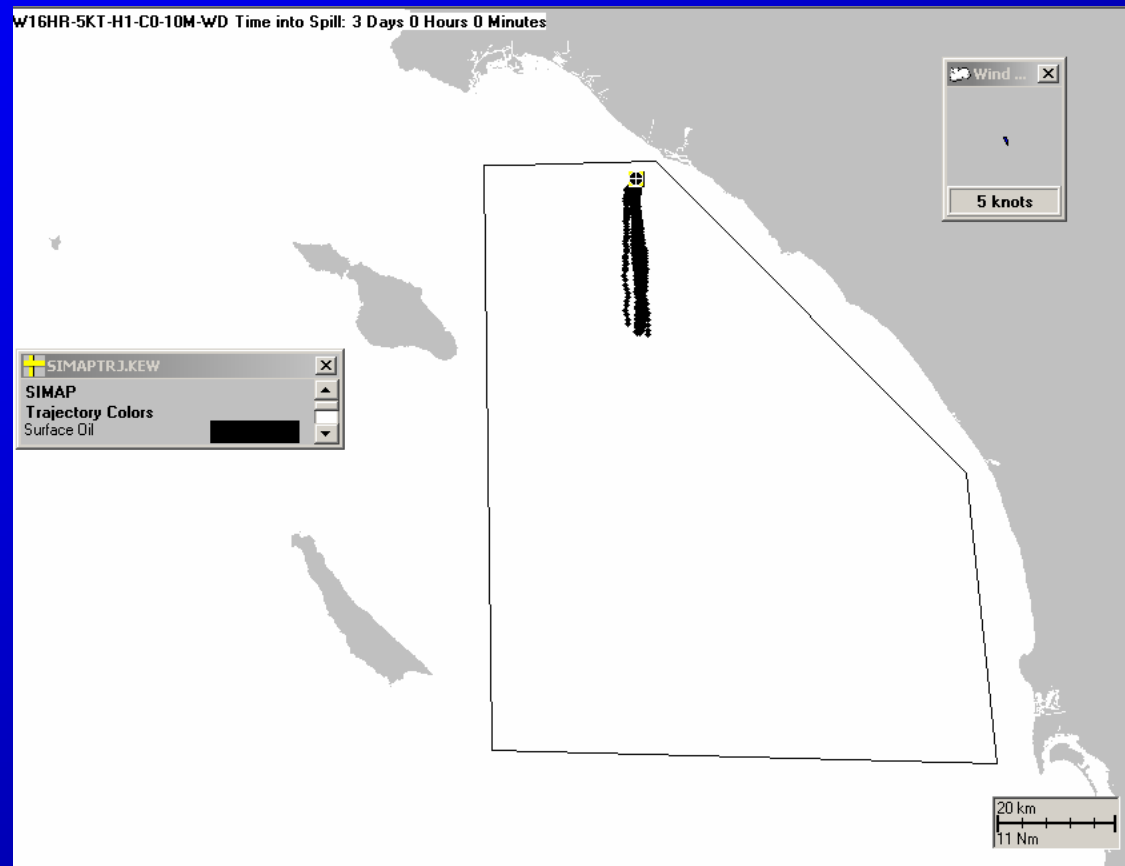


[Polygon indicates area where dispersant could be applied]

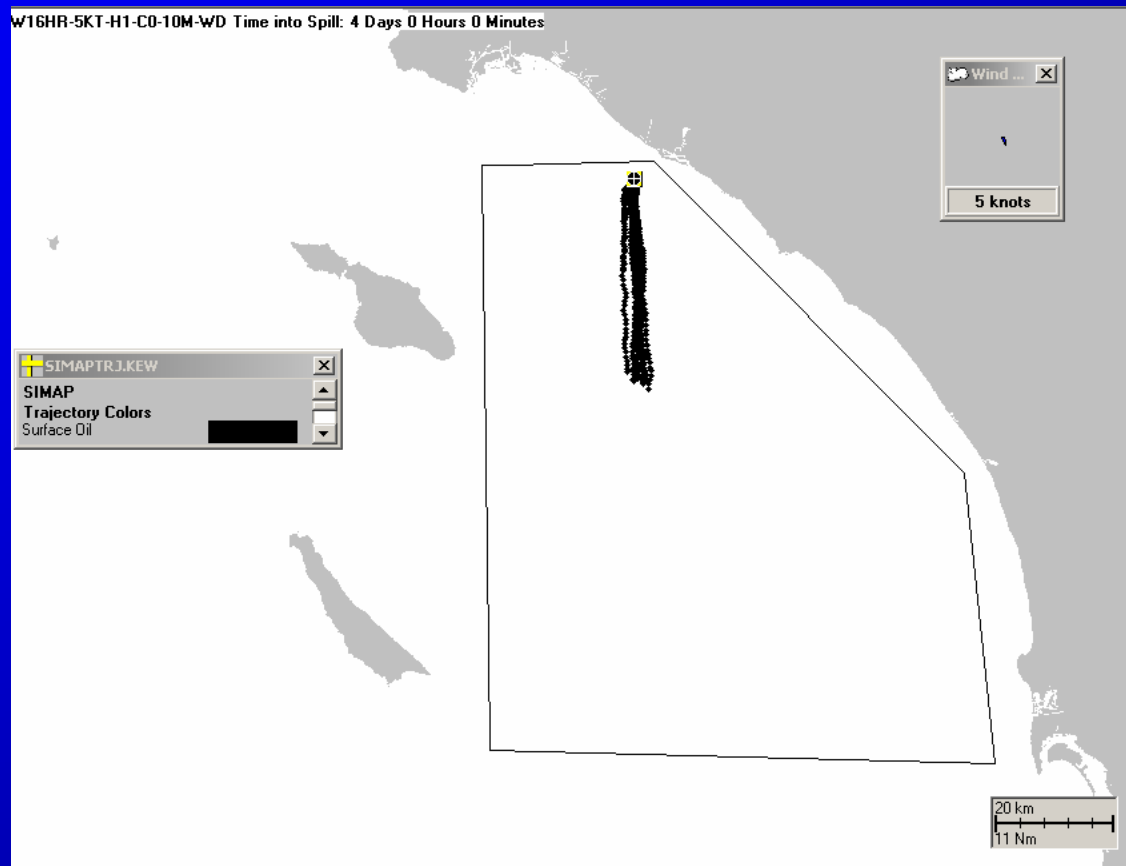
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Dispersant: at 16 hrs; Turbulent mixing to 10m  
deep;  
Trajectory: 48 hrs after dispersant application**



**Wind from NNW 5 kts; Currents: 0 kt;  
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deep;  
Trajectory: 72 hrs after dispersant application**



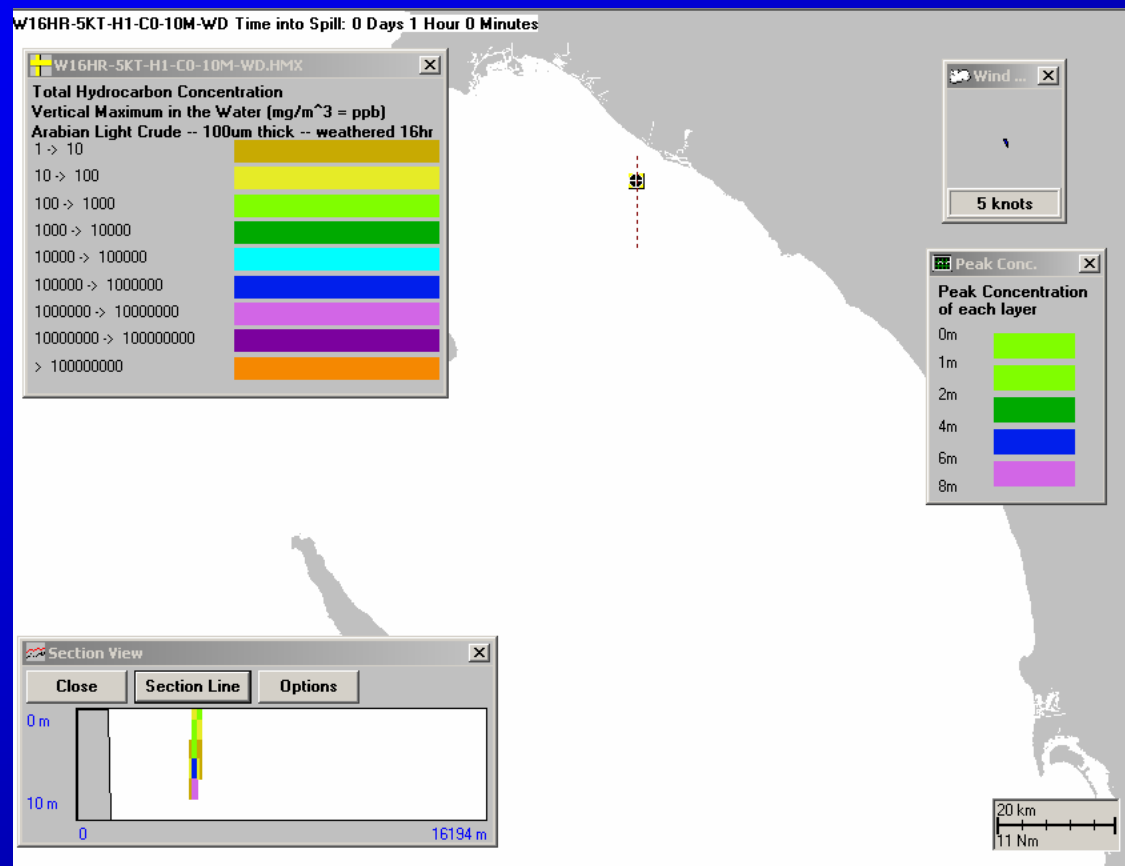
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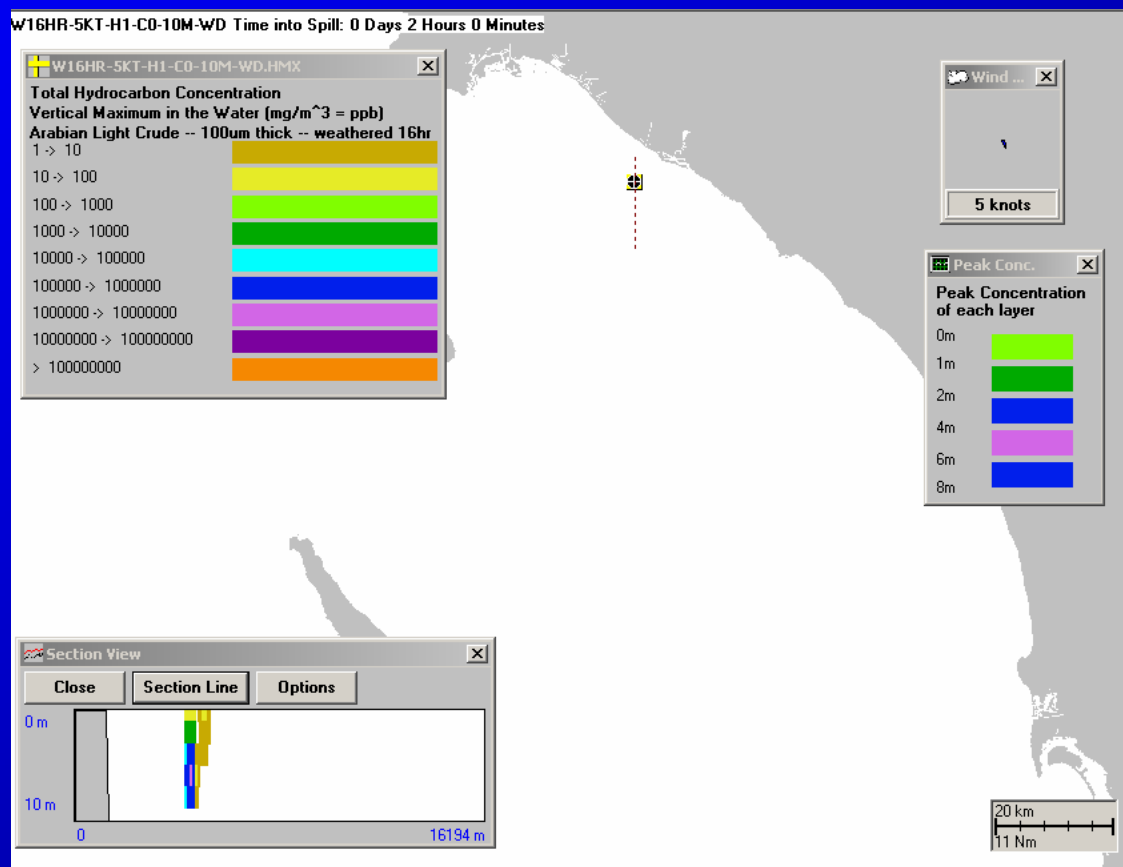


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Subsurface Oil Droplet Concentrations**

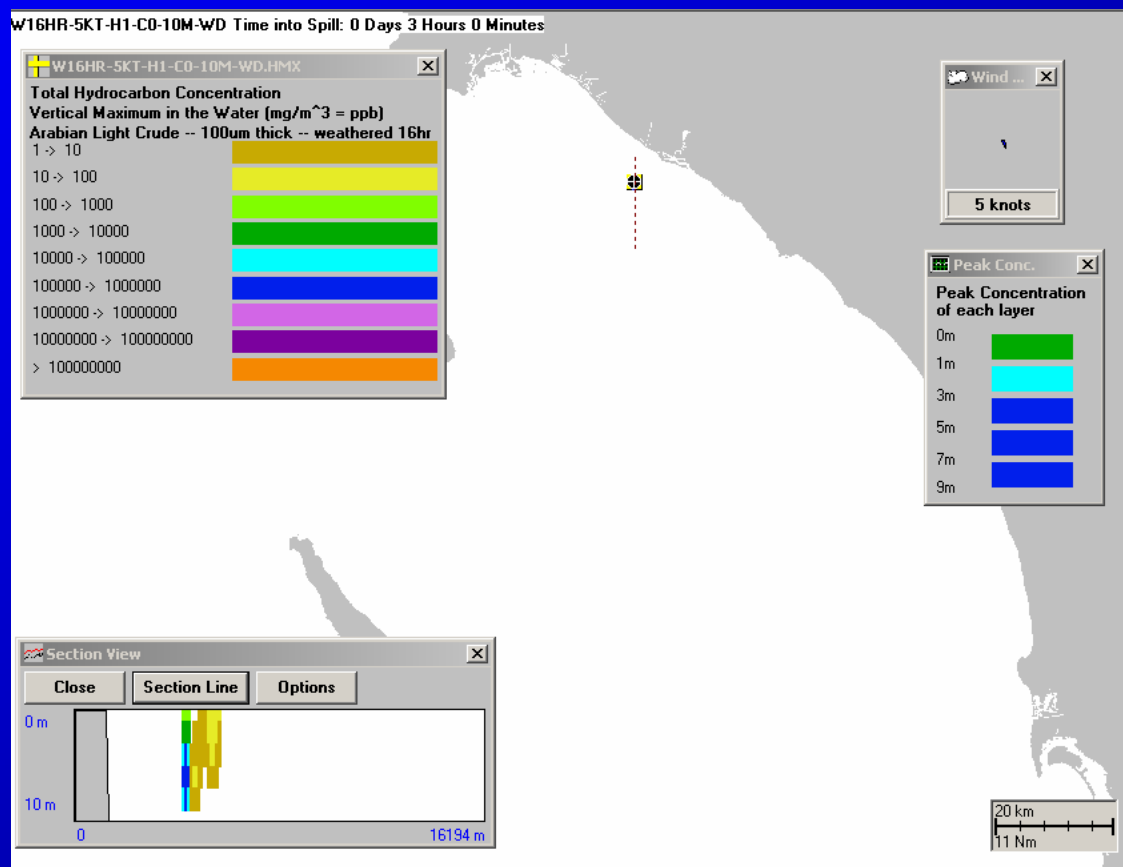
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16hrs; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 1 hr after dispersant application**



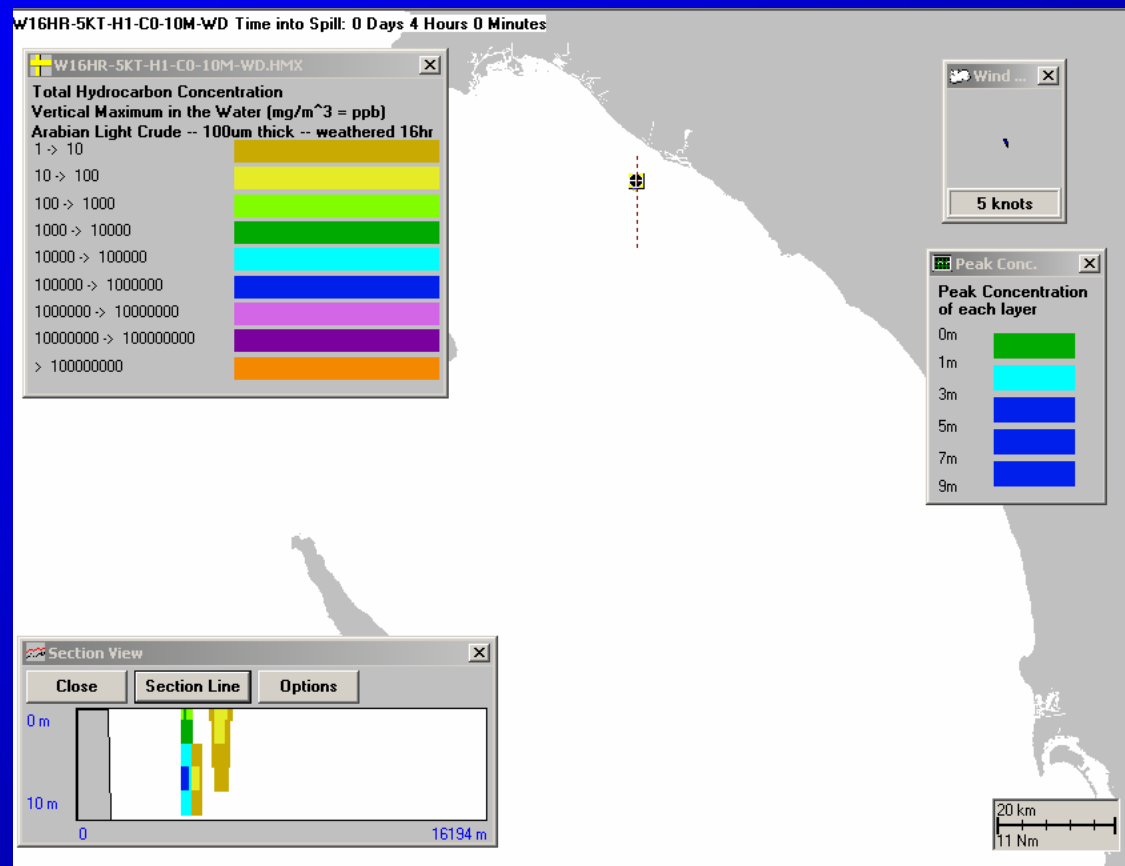
**Wind from NNW 5 kts; Currents: 0 kt;**  
**Dispersant: at 16hrs; Turbulent mixing to 10m deep;**  
**Subsurface Oil Droplet Concentrations: 2 hrs after dispersant application**



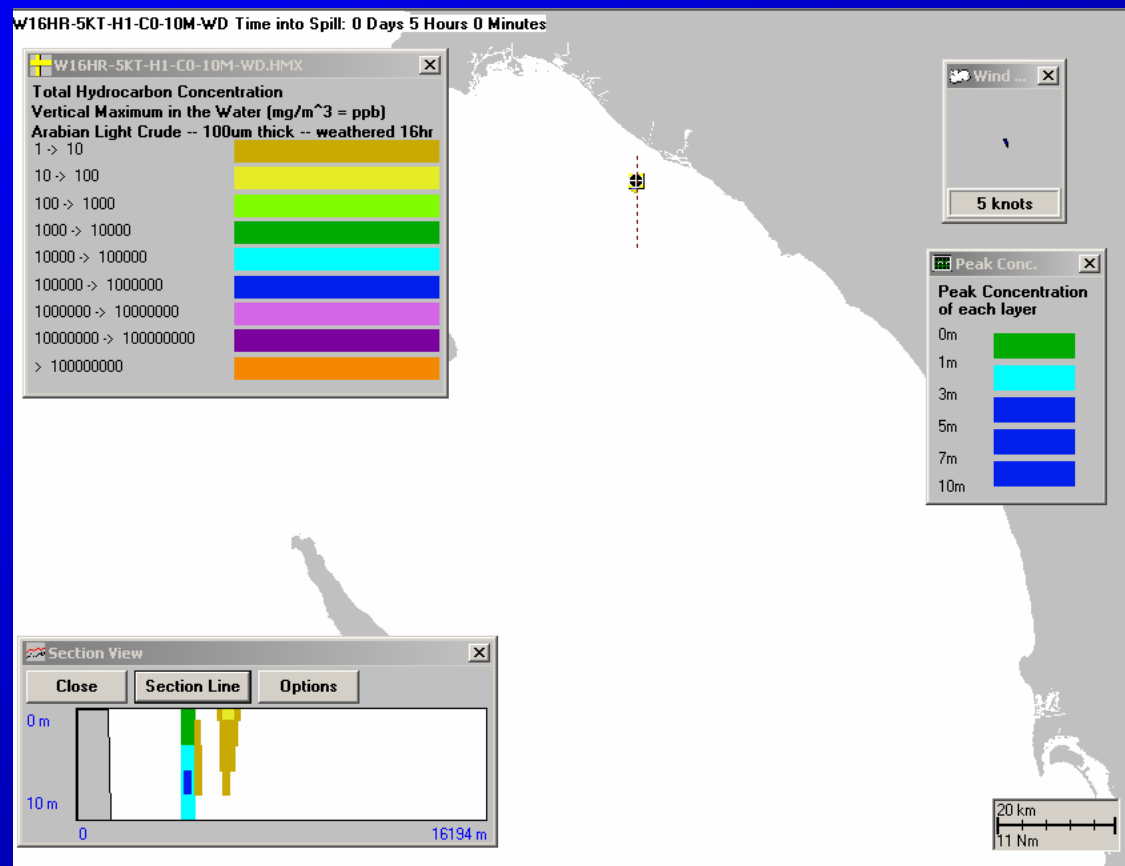
**Wind from NNW 5 kts; Currents: 0 kt;**  
**Dispersant: at 16hrs; Turbulent mixing to 10m deep;**  
**Subsurface Oil Droplet Concentrations: 3 hrs after dispersant application**



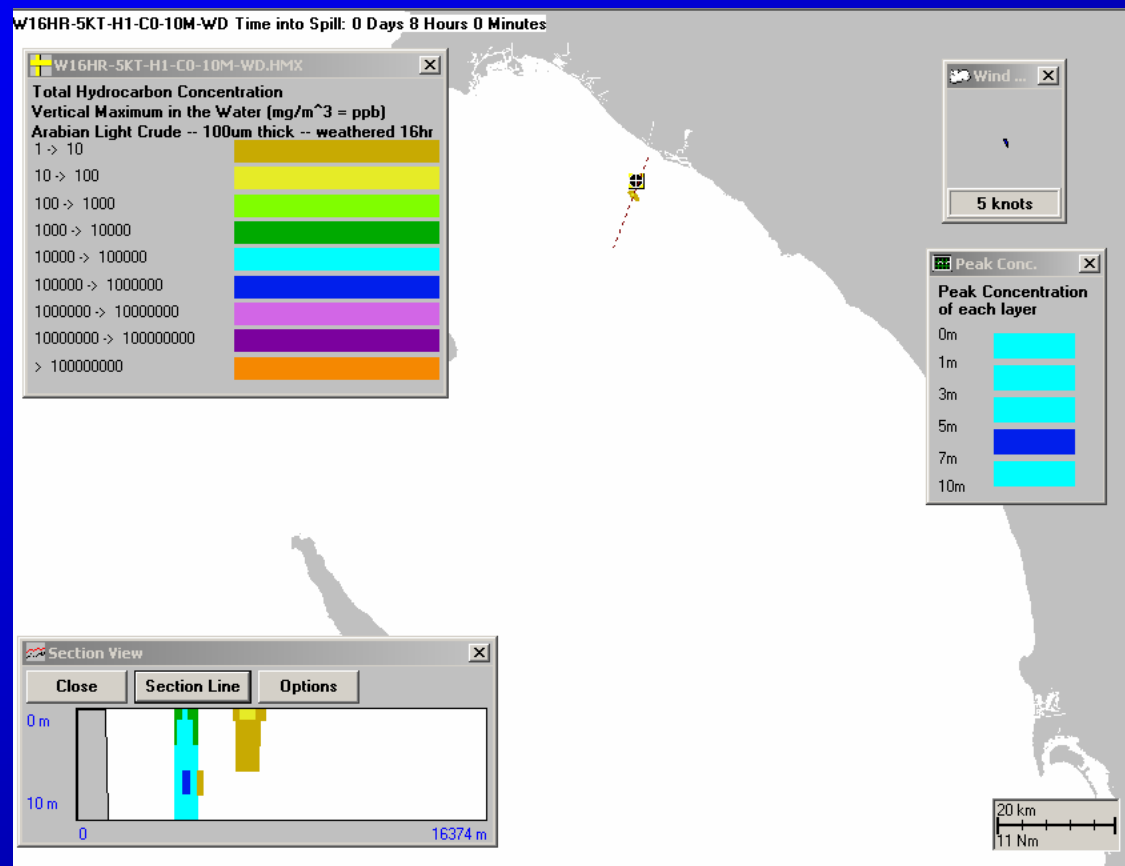
**Wind from NNW 5 kts; Currents: 0 kt;**  
**Dispersant: at 16hrs; Turbulent mixing to 10m deep;**  
**Subsurface Oil Droplet Concentrations: 4 hrs after dispersant application**



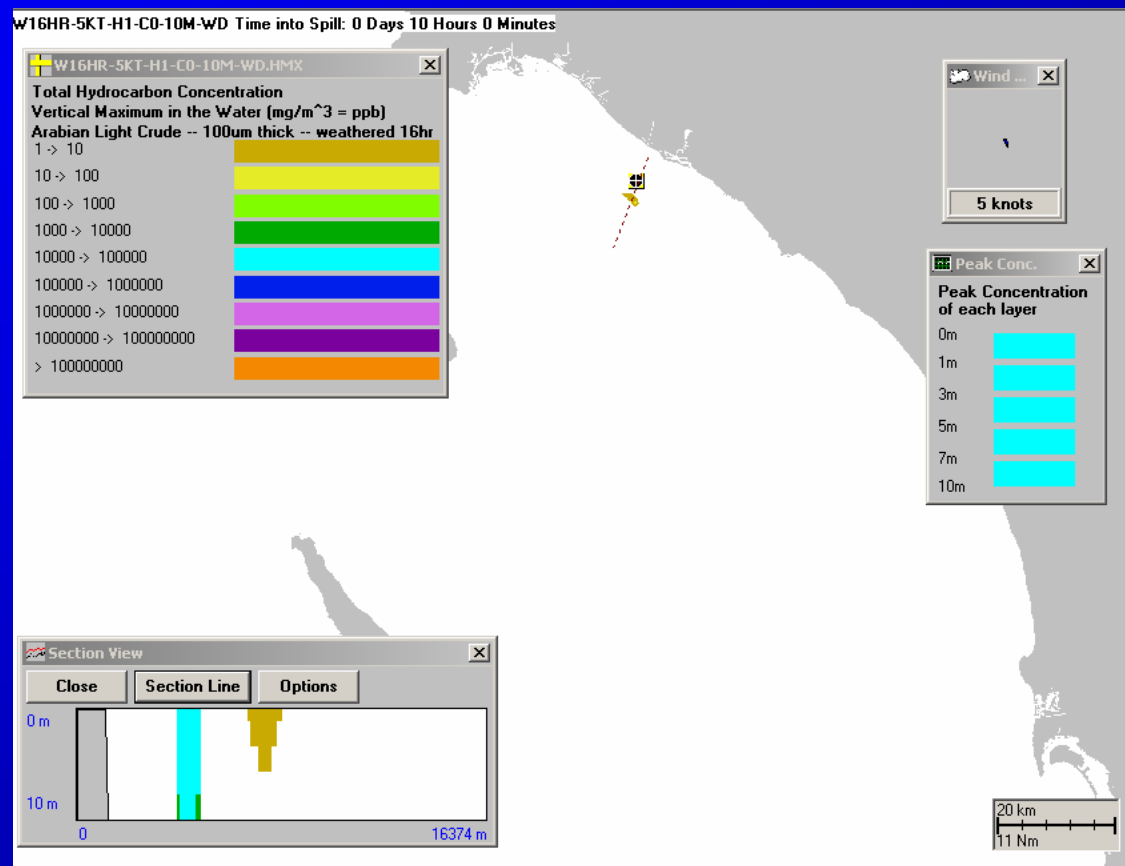
**Wind from NNW 5 kts; Currents: 0 kt;**  
**Dispersant: at 16hrs; Turbulent mixing to 10m deep;**  
**Subsurface Oil Droplet Concentrations: 5 hrs after dispersant application**



**Wind from NNW 5 kts; Currents: 0 kt;**  
**Dispersant: at 16hrs; Turbulent mixing to 10m deep;**  
**Subsurface Oil Droplet Concentrations: 8 hrs after dispersant application**

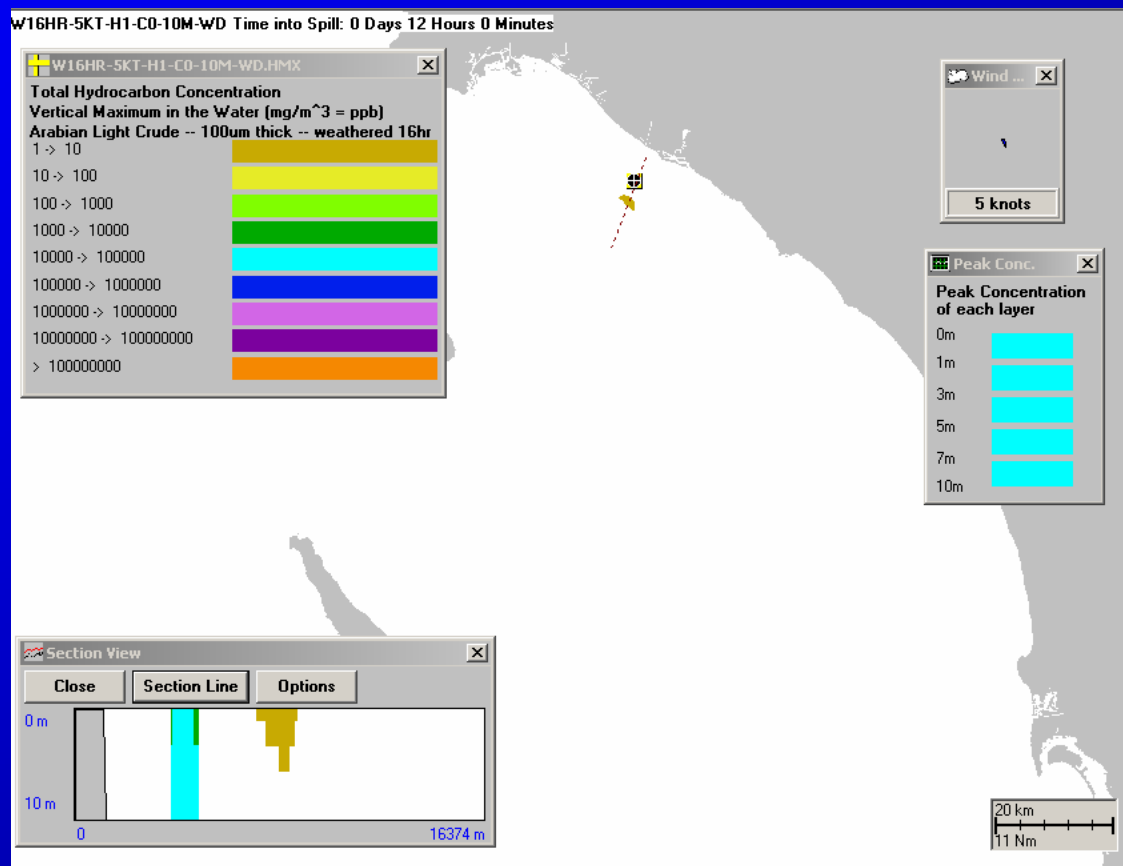


**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16hrs; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 10 hrs after dispersant  
application**

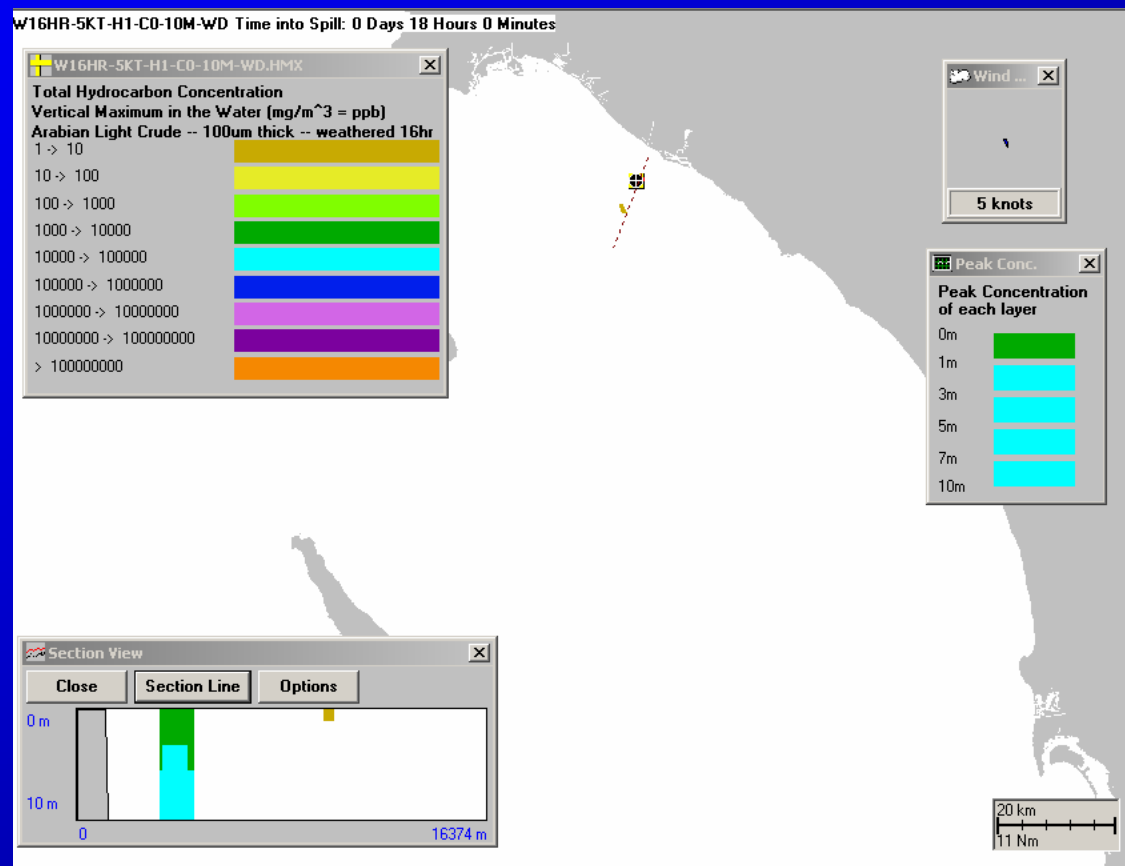




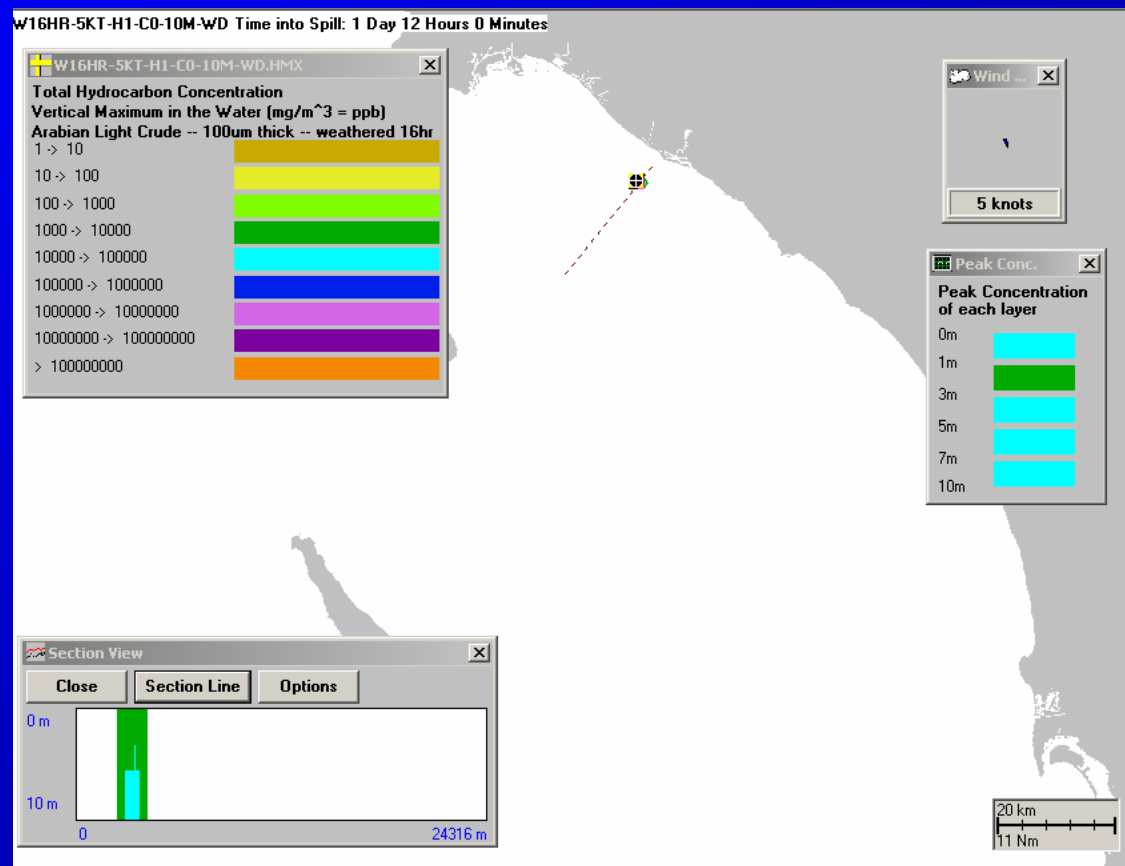
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application**



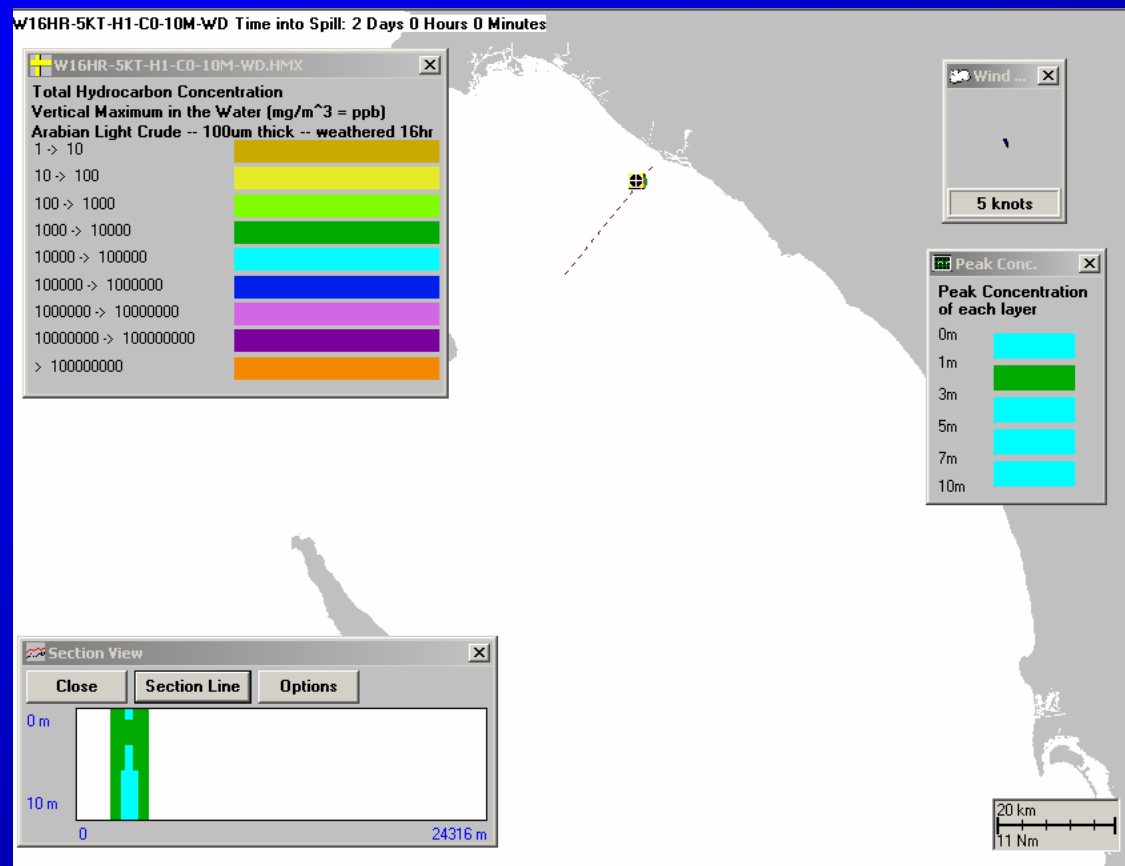
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Dispersant: at 16hrs; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 18 hrs after dispersant  
application**



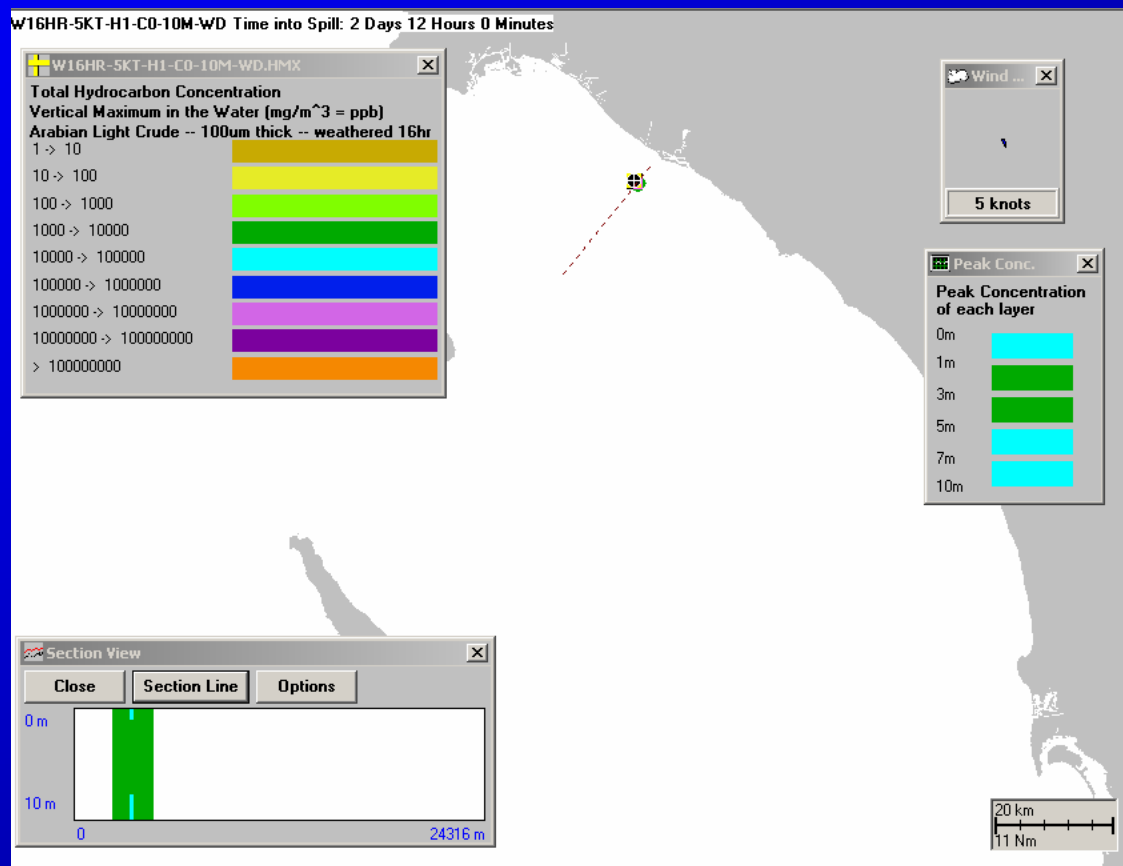
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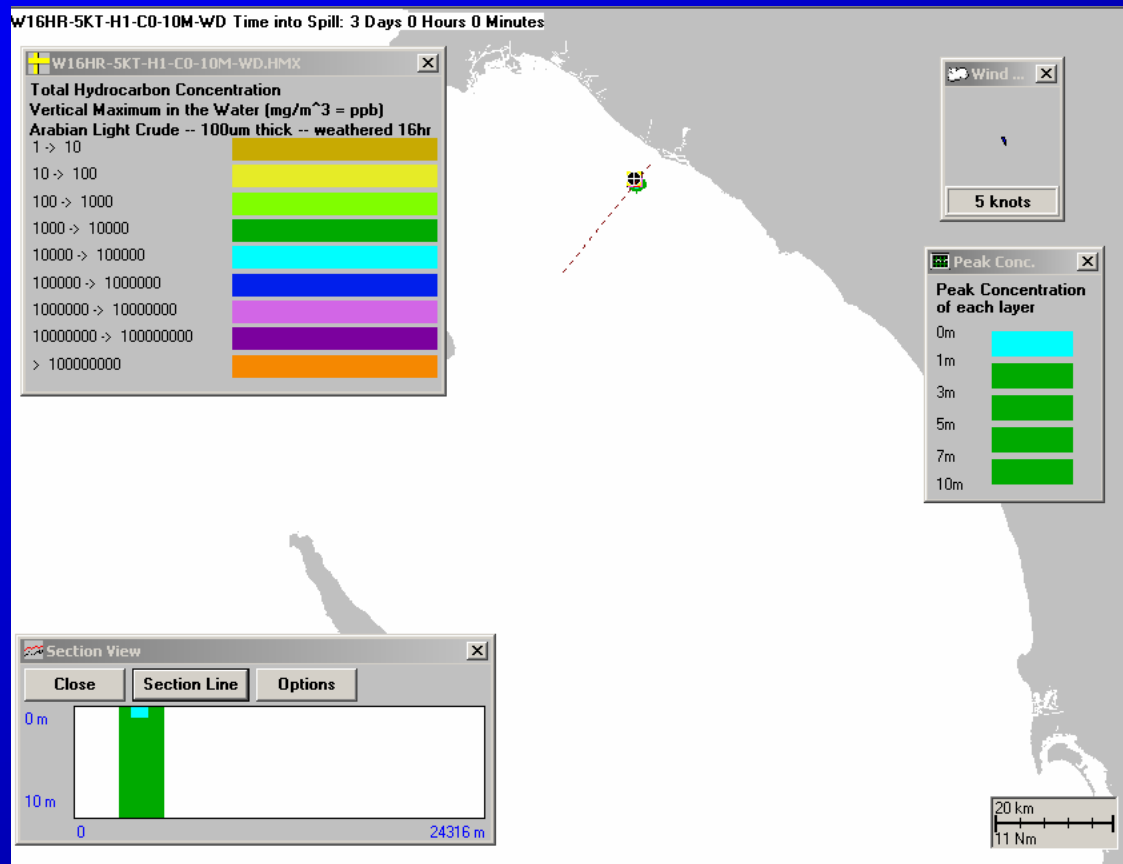
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Subsurface Oil Droplet Concentrations: 48 hrs after dispersant  
application**



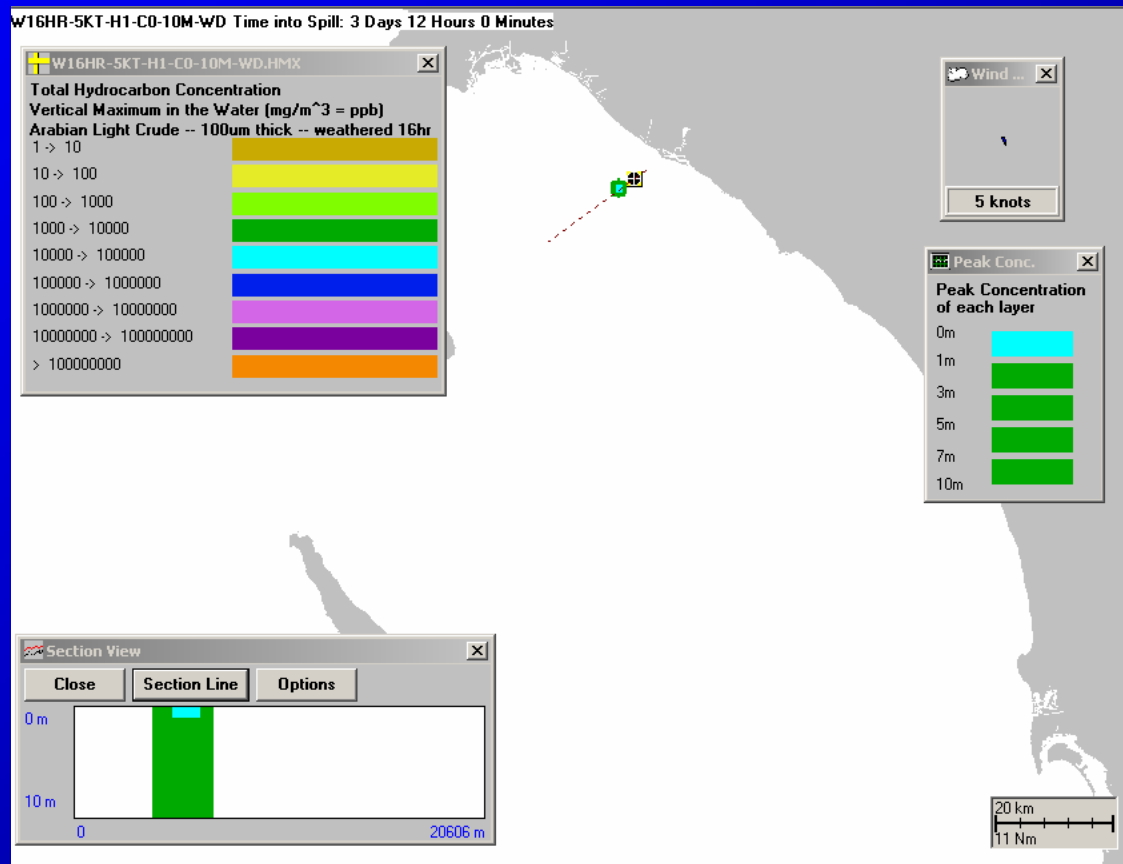
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Dispersant: at 16hrs; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 60 hrs after dispersant  
application**



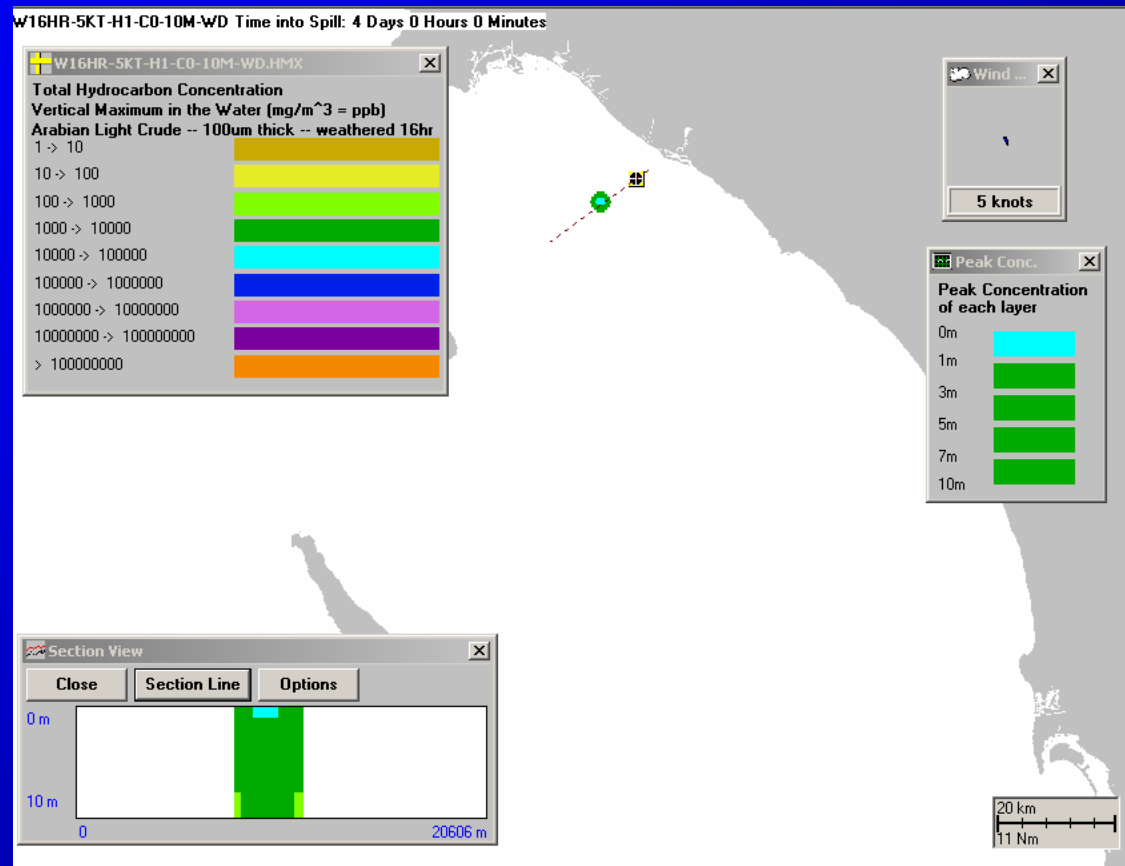
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**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16hrs; Turbulent mixing to 10m deep;  
Subsurface Oil Droplet Concentrations: 84 hrs after dispersant  
application**



**Wind from NNW 5 kts; Currents: 0 kt;  
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Subsurface Oil Droplet Concentrations: 96 hrs after dispersant  
application**

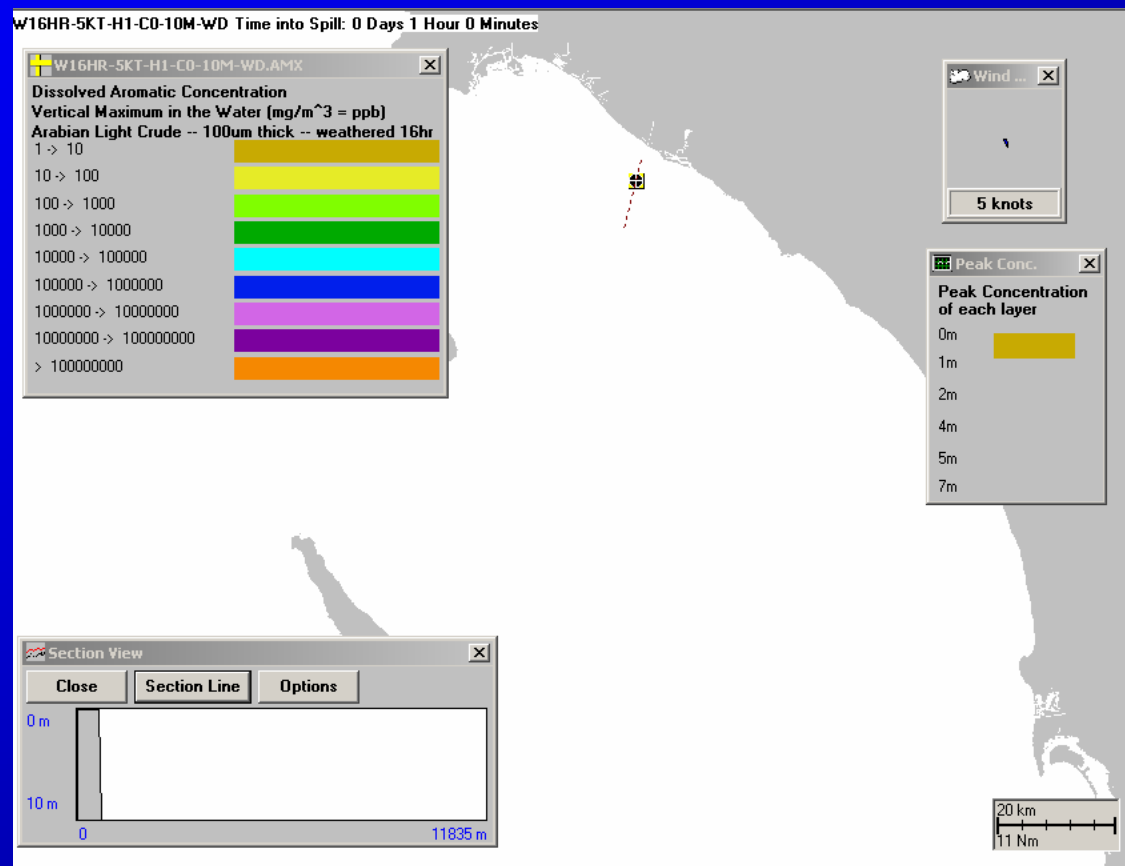




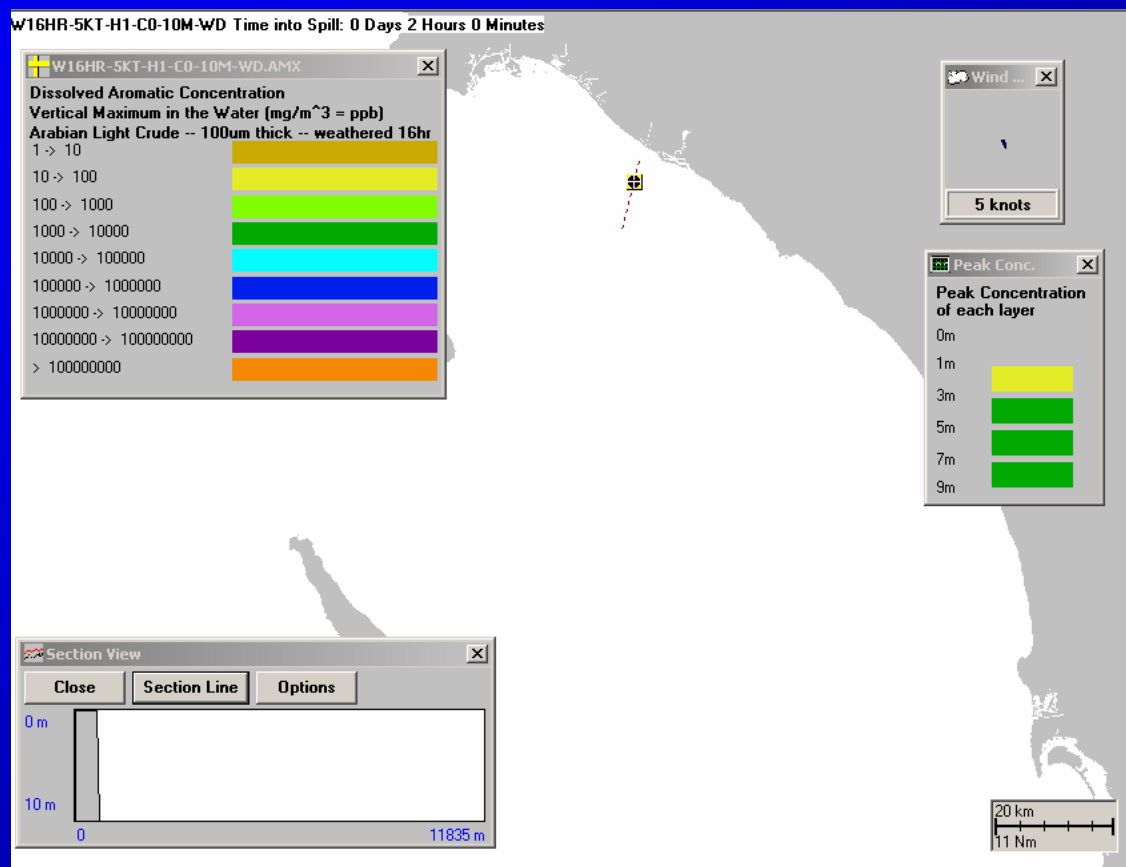
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10m deep;**

**Dissolved Aromatic Concentrations**

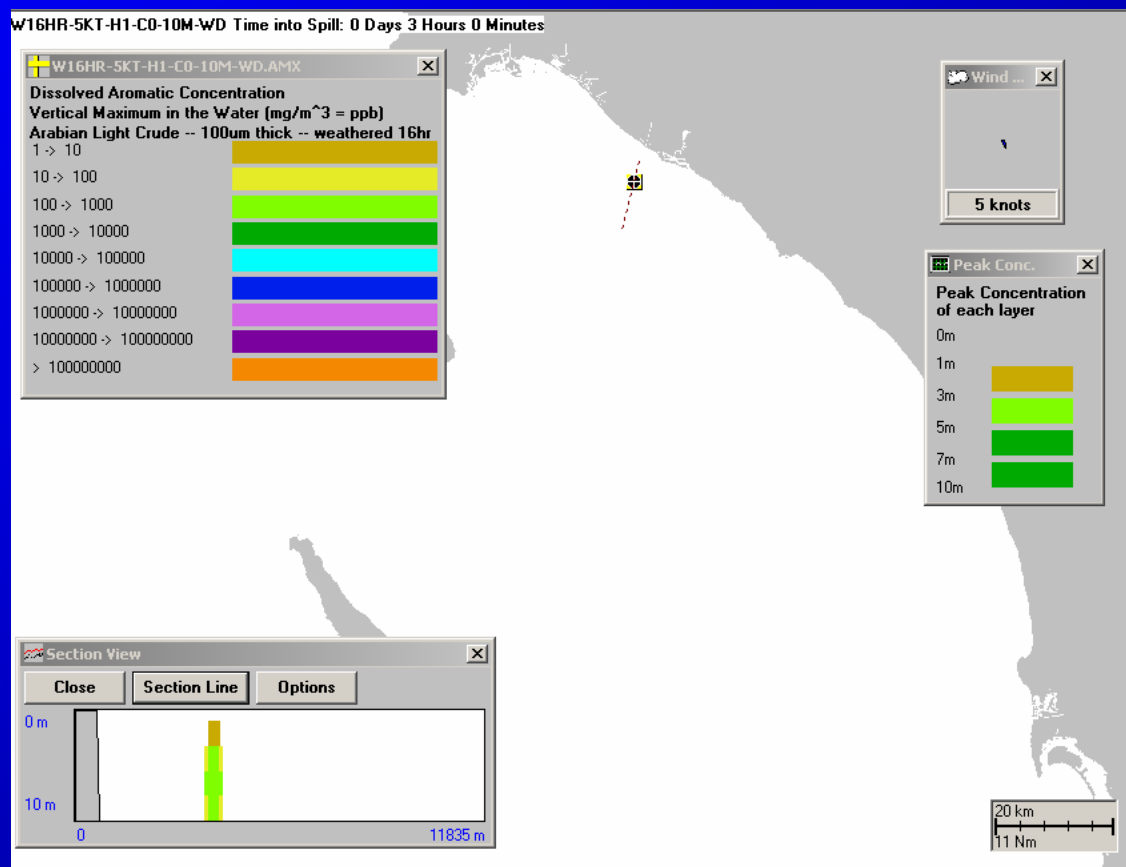
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 1 hr after dispersant application**



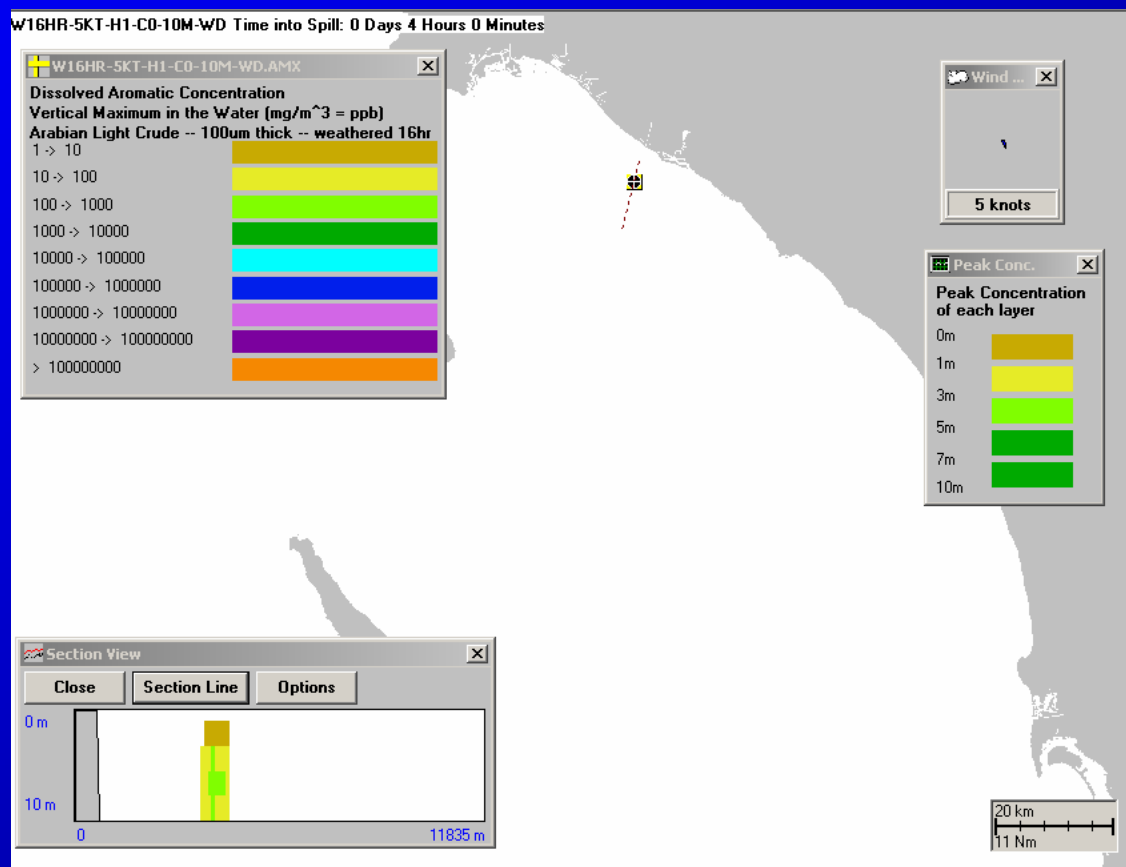
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 2 hrs after dispersant application**



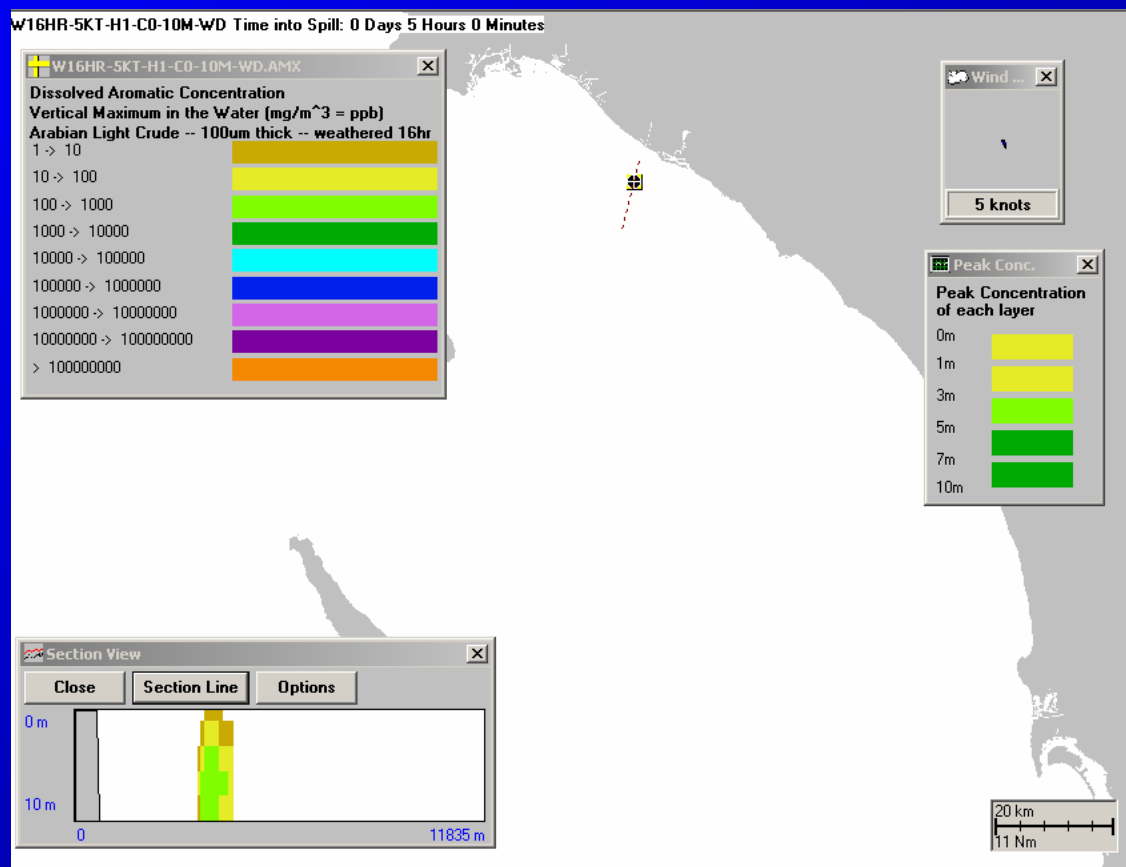
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 3 hrs after dispersant application**



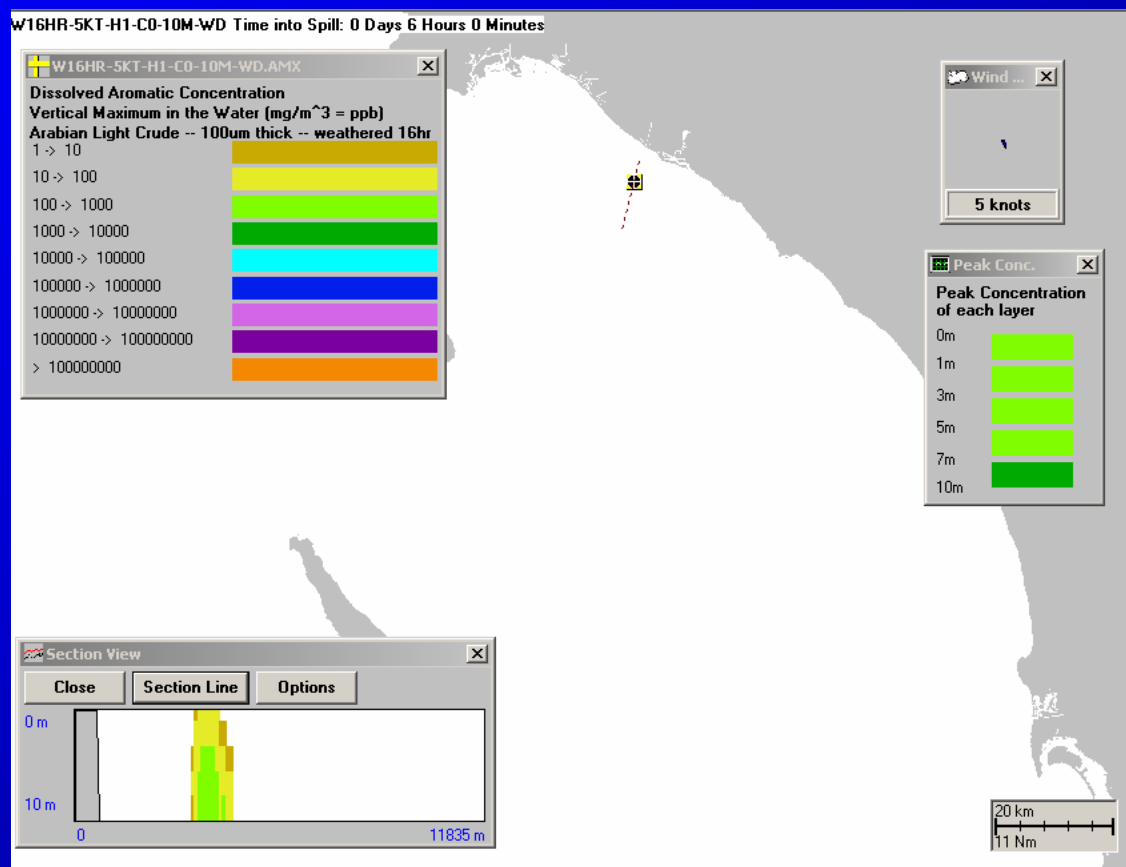
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 4 hrs after dispersant application**



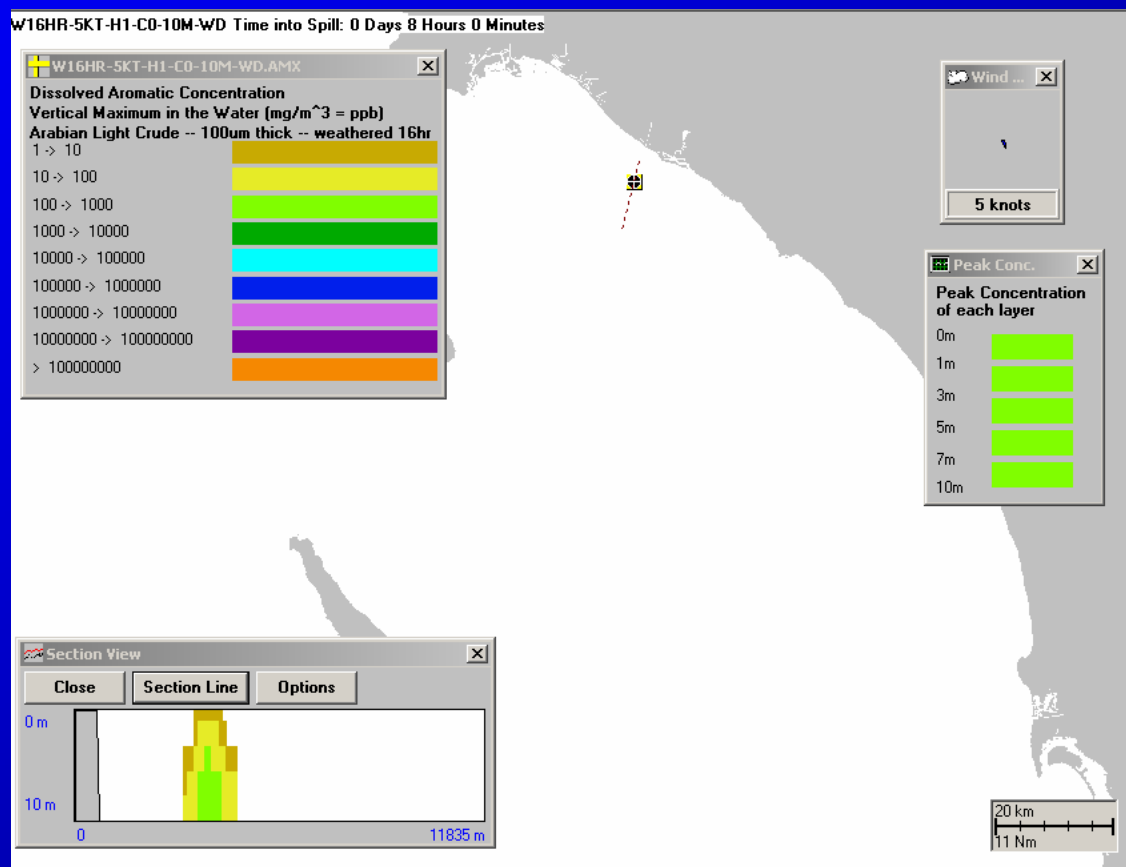
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 5 hrs after dispersant application**



**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 6 hrs after dispersant application**

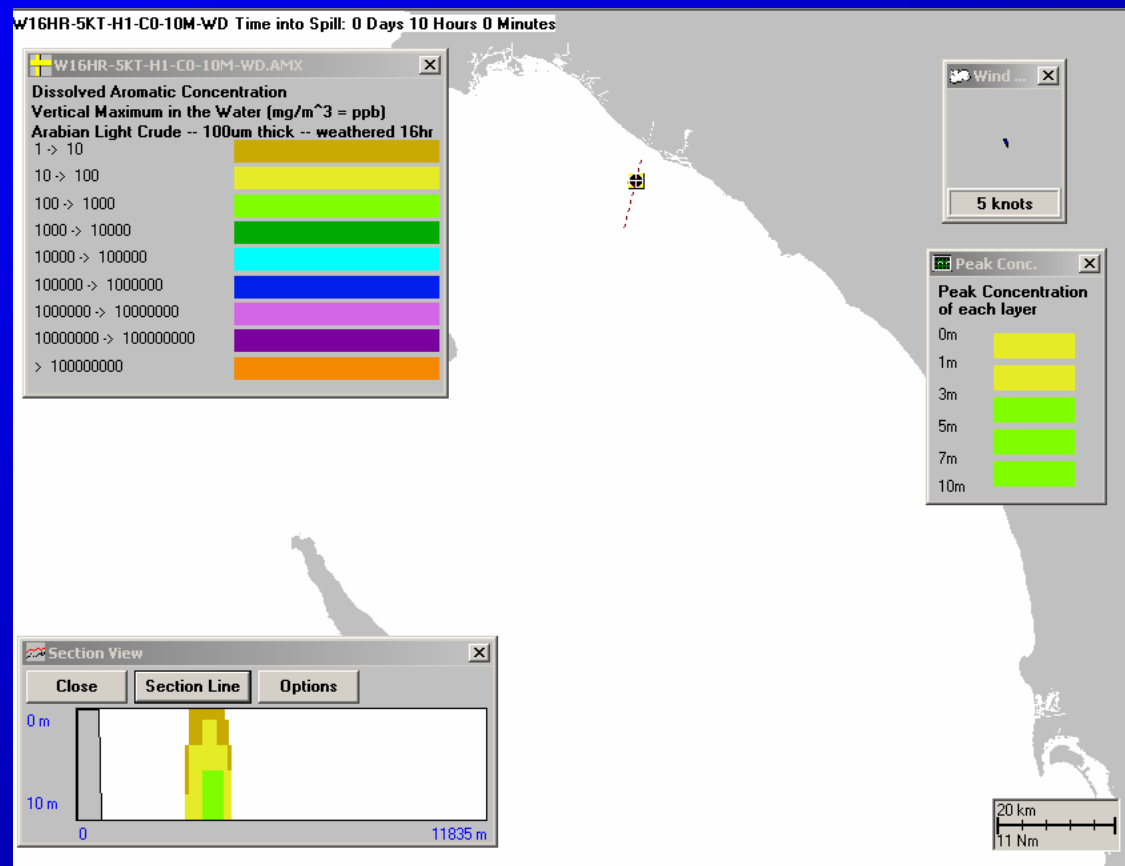


**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 8 hrs after dispersant application**

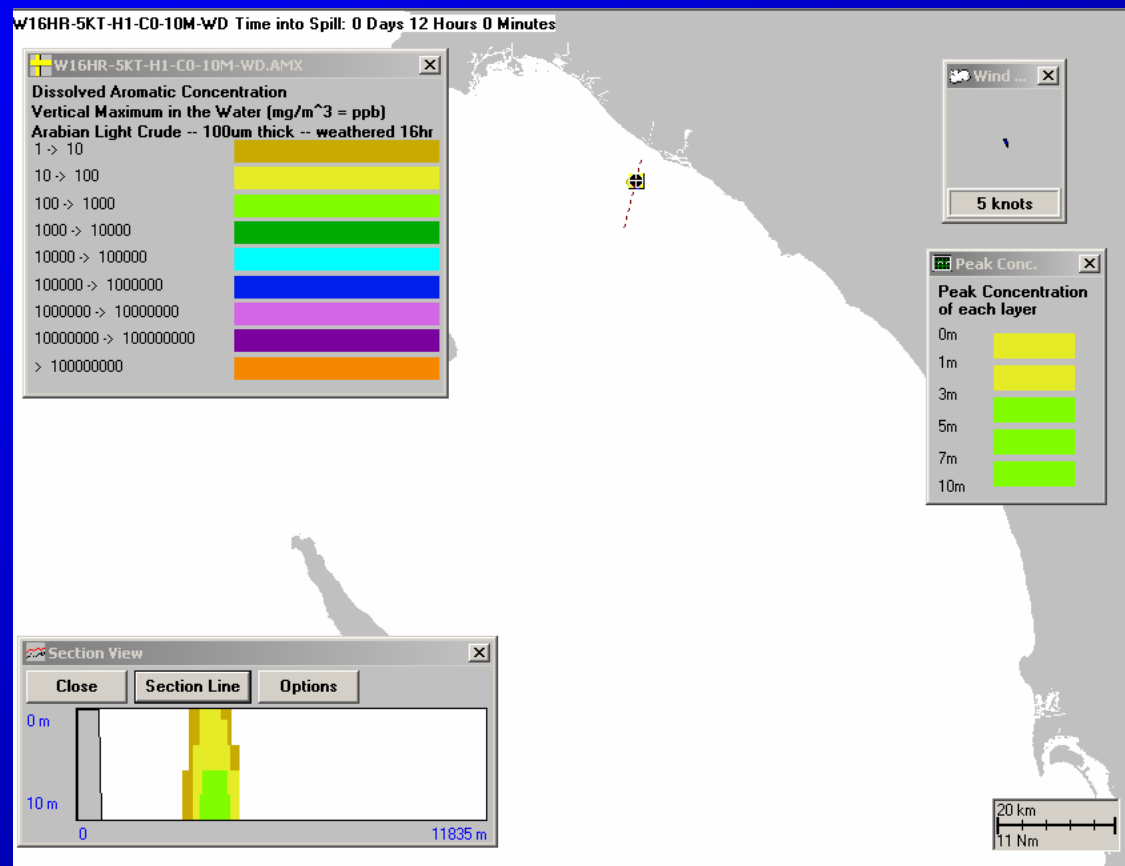




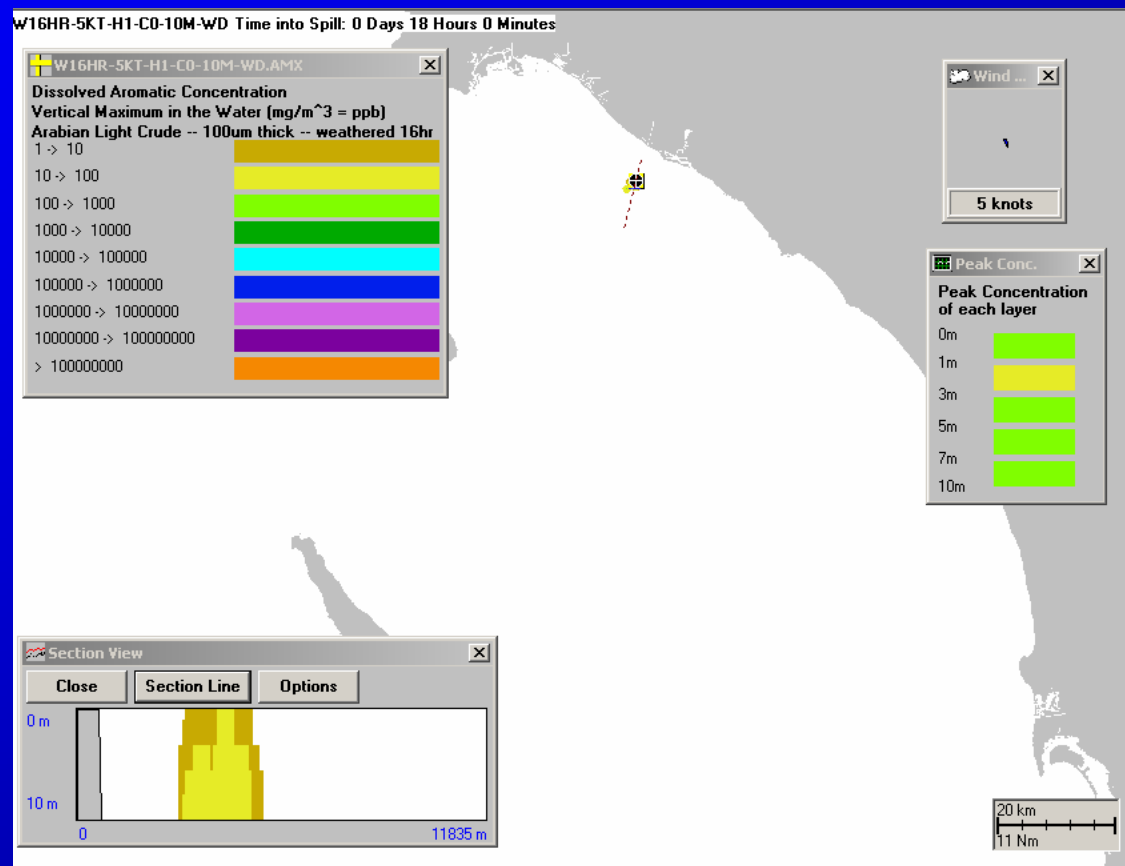
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 10 hrs after dispersant application**



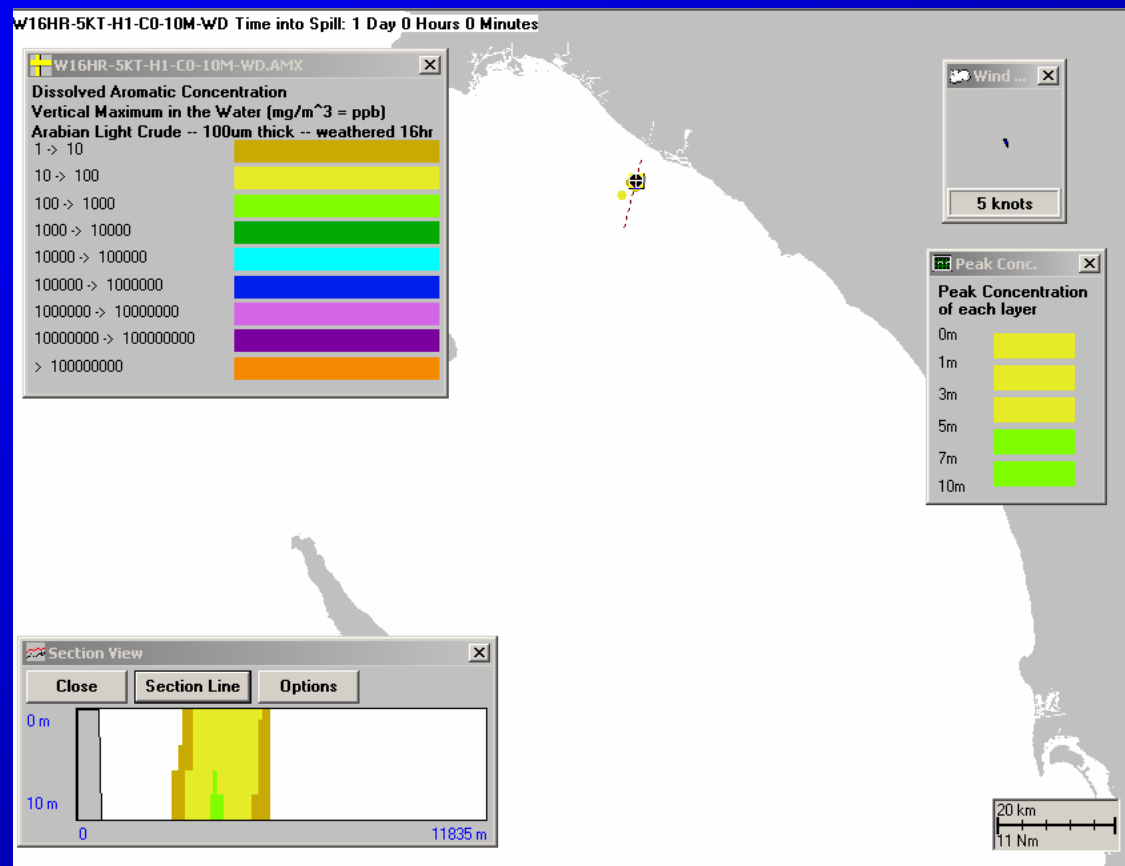
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 12 hrs after dispersant application**



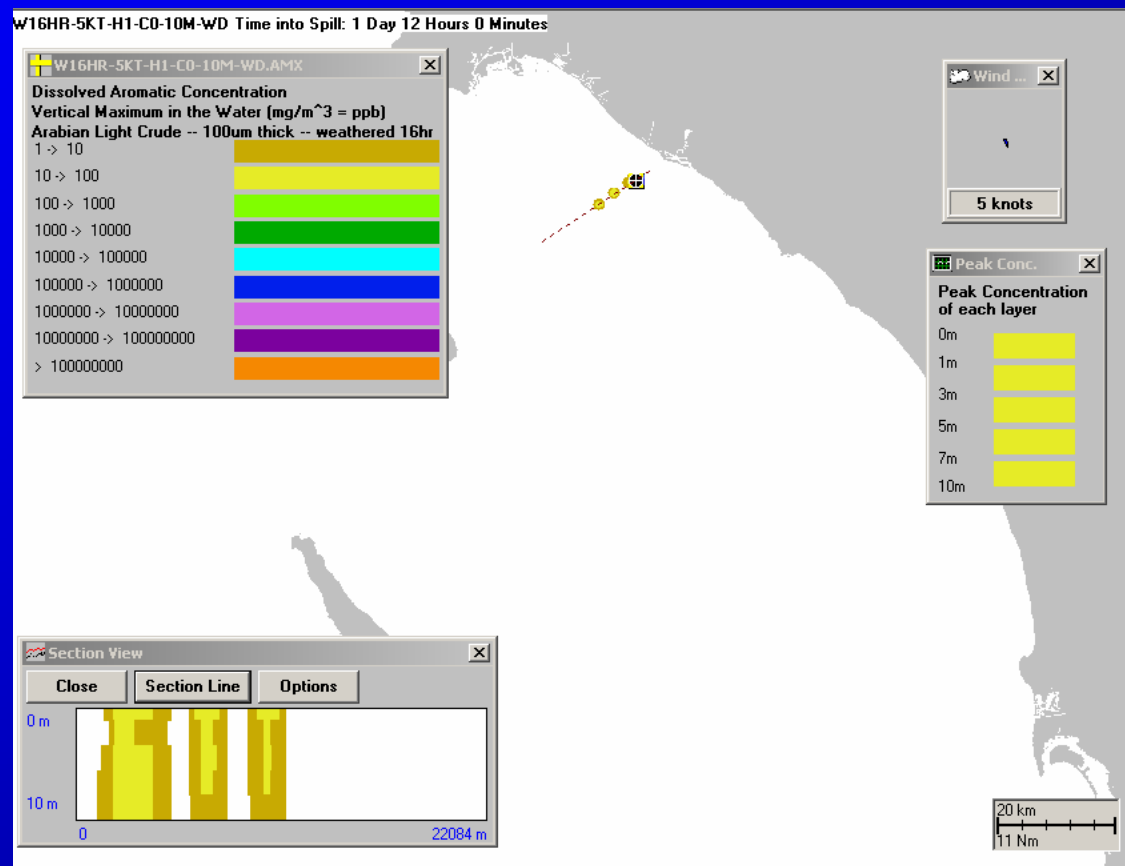
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 18 hrs after dispersant application**



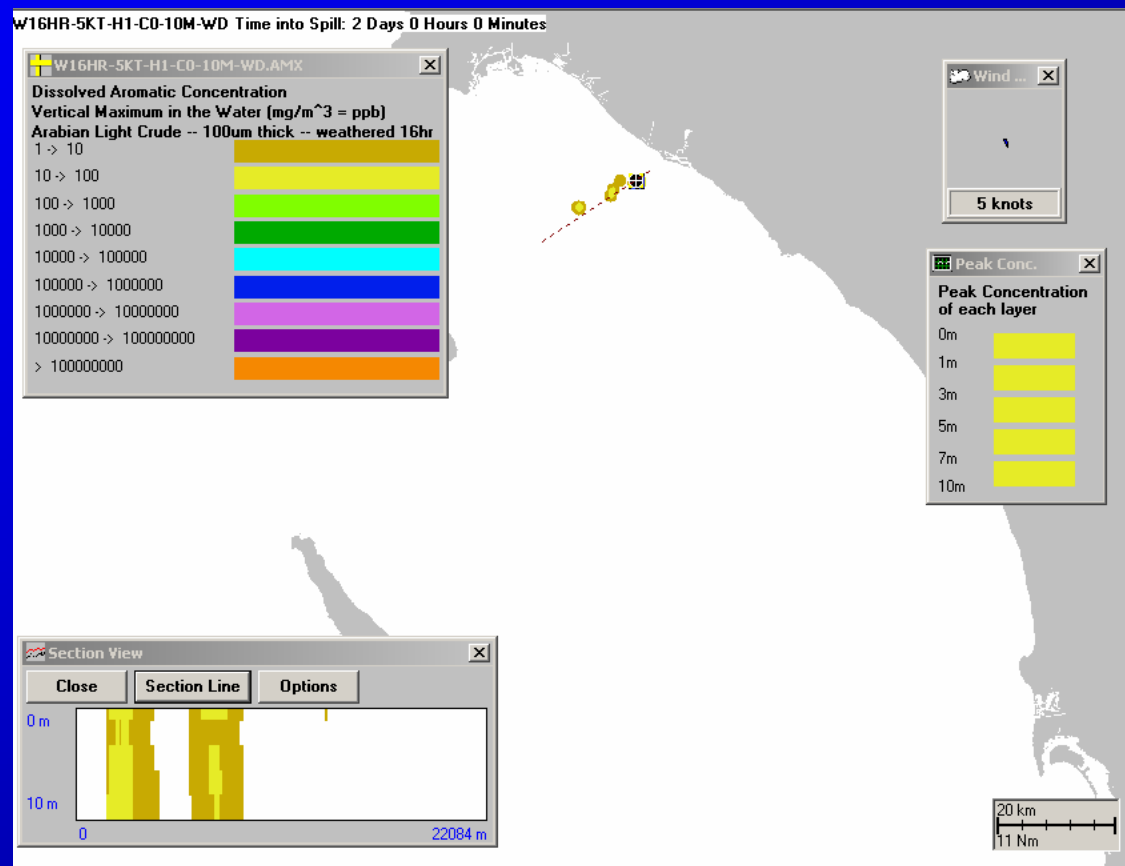
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 24 hrs after dispersant application**



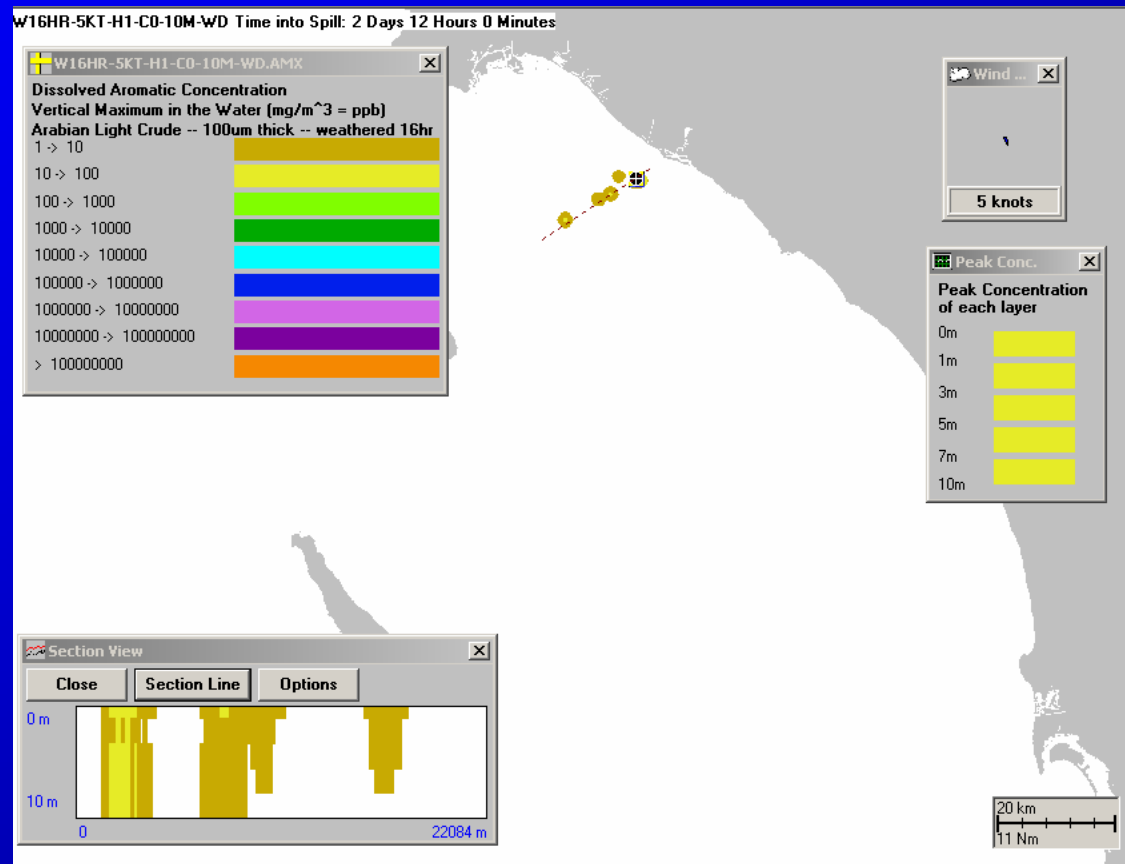
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 36 hrs after dispersant application**



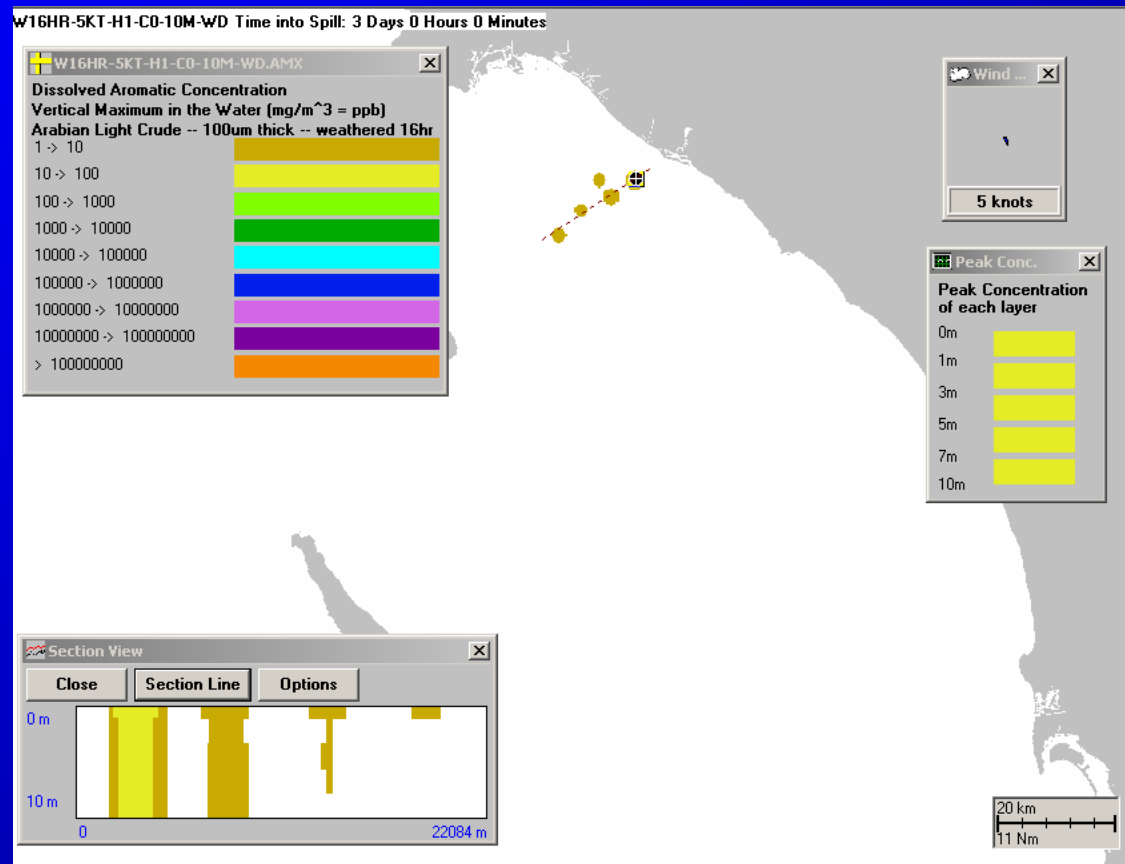
**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 48 hrs after dispersant application**



**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 60 hrs after dispersant application**

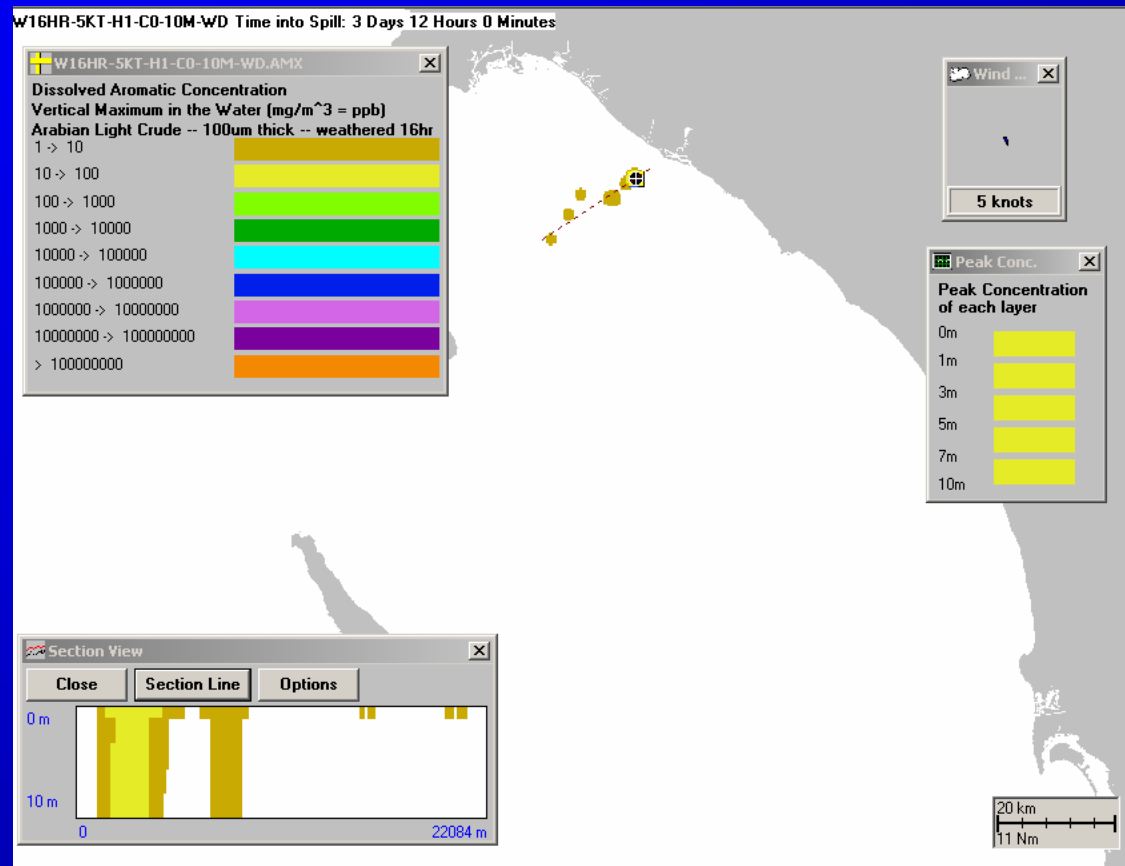


**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 72 hrs after dispersant application**

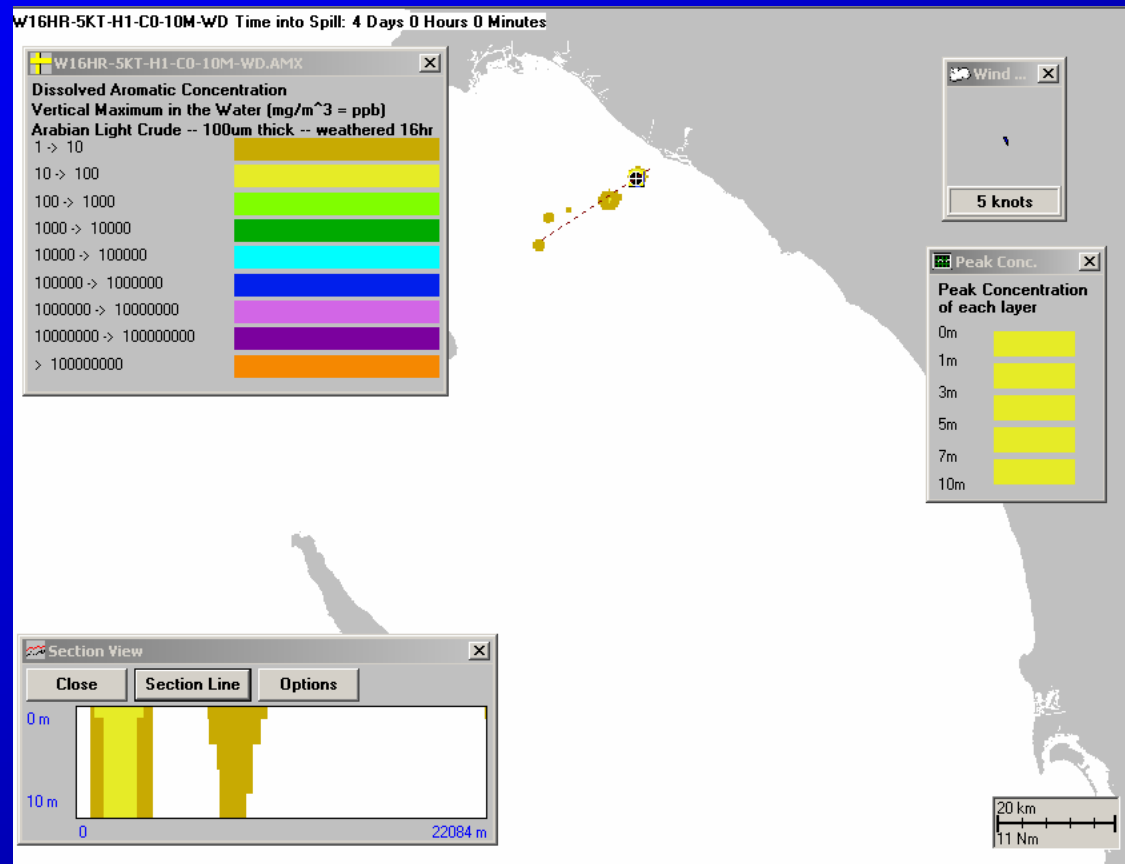




**Wind from NNW 5 kts; Currents: 0 kt;**  
**Dispersant: at 16 hrs; Turbulent mixing to 10m deep;**  
**Dissolved Aromatic Concentrations: 84 hrs after dispersant application**



**Wind from NNW 5 kts; Currents: 0 kt;  
Dispersant: at 16 hrs; Turbulent mixing to 10m deep;  
Dissolved Aromatic Concentrations: 96 hrs after dispersant application**



# **BIOLOGICAL IMPACT**

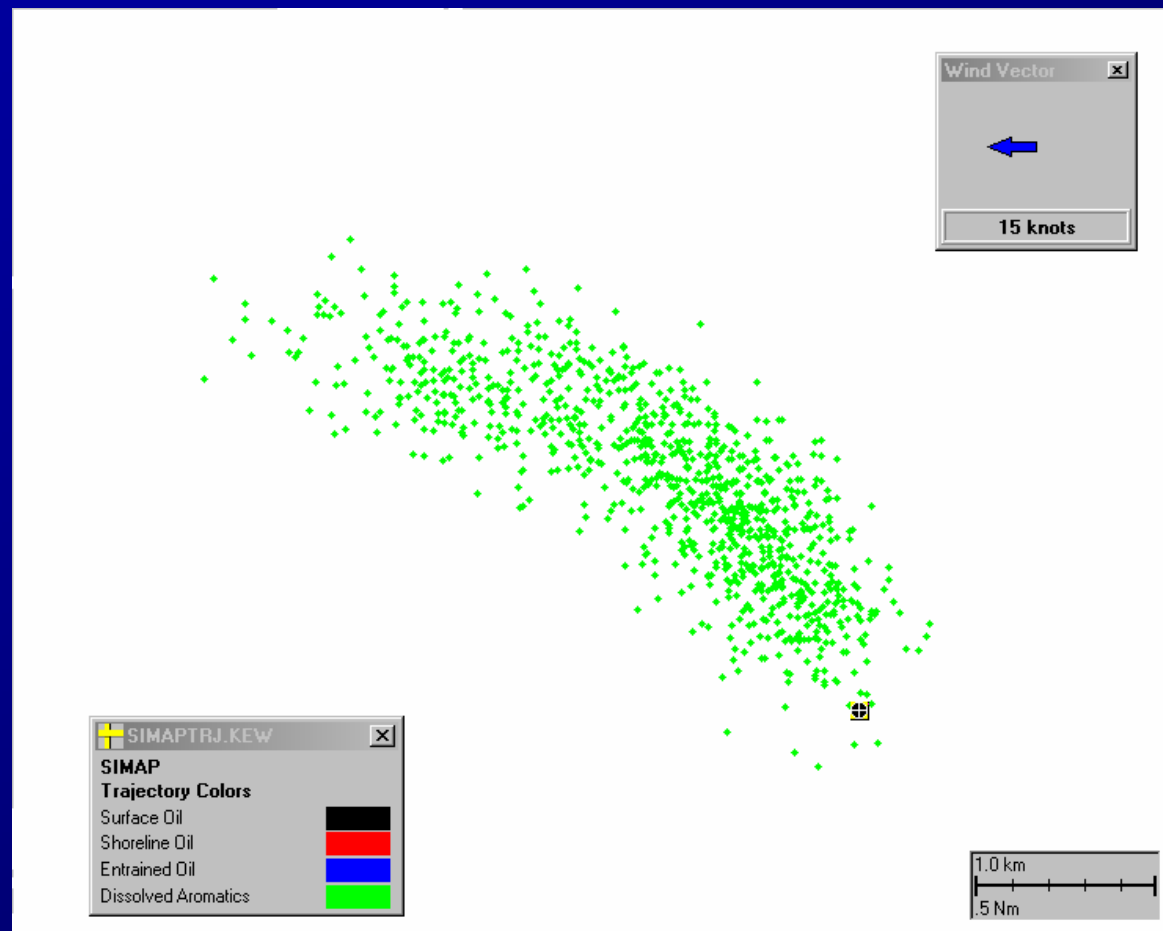
## **Toxicity Requires Exposure**

- Requires Uptake into Organism
  - Some degree of solubility in order for uptake to occur
  - Less soluble components yield lower dissolved concentrations: slower uptake but higher toxicity
- Particulate uptake via gills, organism's surface, or gut
- Concentration that is bio-available
  - Dissolved concentration
  - Small droplets: likely exposure and effects (via dissolved phase)
  - Uptake different for filter-feeders vs. non-filter feeders

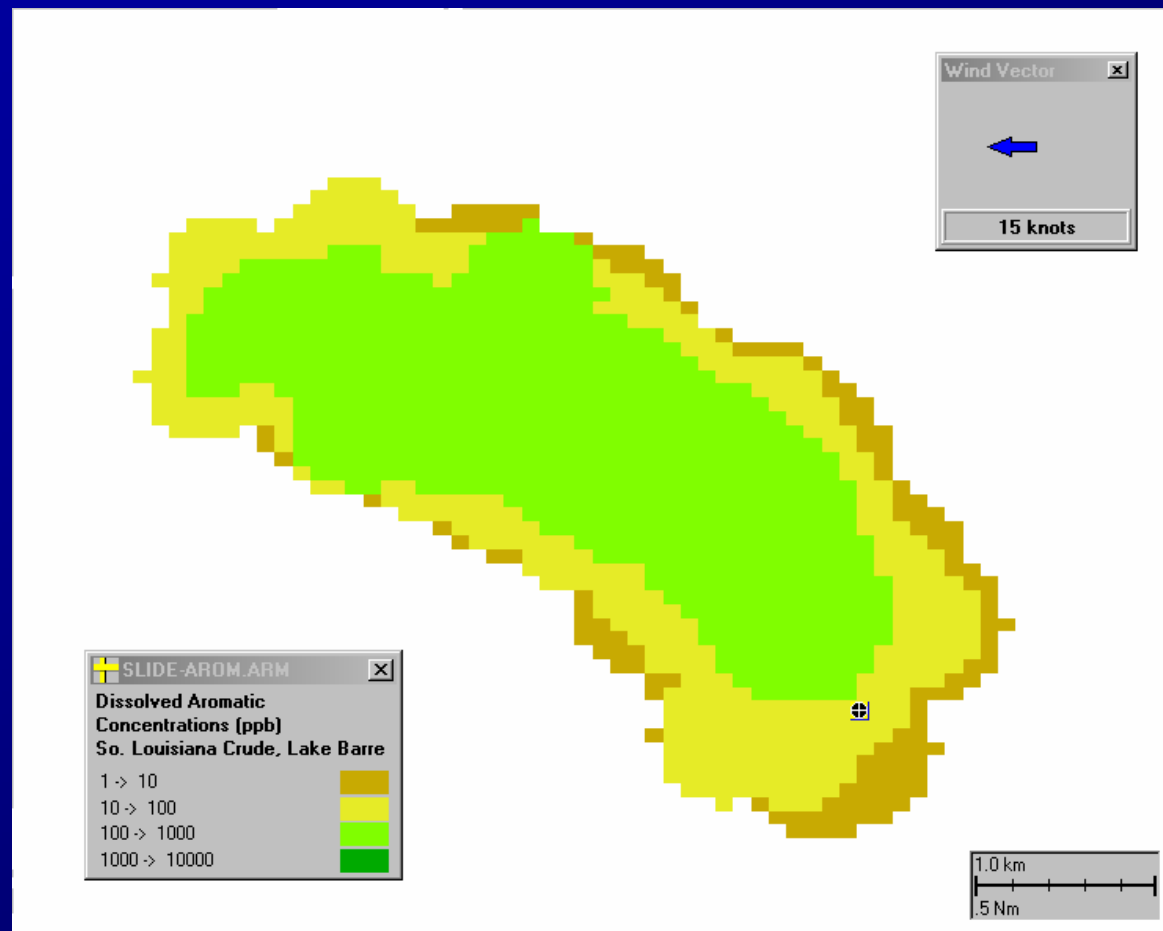
# Oil Toxicity

- 1-3 ring aromatics cause most of acute toxicity
  - in diesel, heavy fuel, and crude oil, most from PAHs
  - for gasoline, MAHs also
- Dissolved aromatic concentration bio-available
- Acute and sublethal effects, narcosis

# Spillets: Dissolved Aromatics



# Concentration Plume Grid

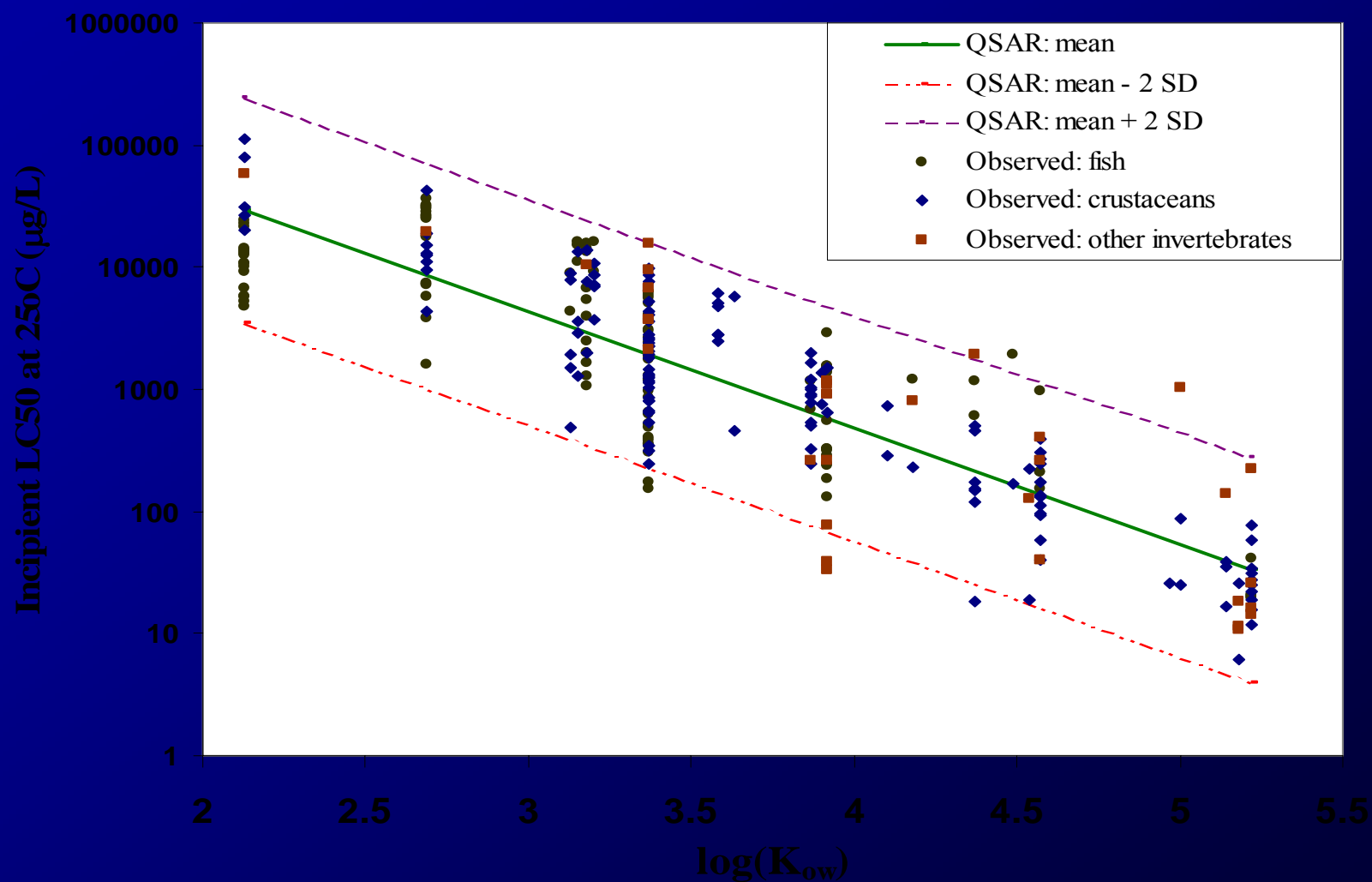


# Biological Exposure Model

- Organisms classified by behavior
  - Wildlife
    - % of time on water surface
    - Habitats used
    - Feathers & fur
  - Fish and Invertebrates
    - Swimming
    - Drift with currents
    - Stationary
    - Migrations
- Impact a function of dose
  - Wildlife
    - Area swept by oil
    - Oil thickness
  - Fish and Invertebrates
    - Concentration
    - Exposure time
    - Temperature
- Movements of organisms are tracked to calculate exposure of individuals

# Aromatic toxicity – regression of bioassay $LC_{50}$ vs. index of affinity to lipid ( $\log K_{ow}$ )

Bioassay data from the literature: tests for all species.





# Biological exposure model

Computation  $LC_{50}$  values for acute toxic effects for 3 sensitivity levels:

- 2.5<sup>th</sup> percentile sensitivity – 5  $\mu\text{g/L}$  (ppb) of PAH
- Average sensitivity – 50  $\mu\text{g/L}$  (ppb) of PAH
- 97.5<sup>th</sup> percentile sensitivity – 400  $\mu\text{g/L}$  of PAH

# RESULTS

## SIMAP Matrix of Runs:

- 1 location off SoCal
- 1 oil type = light Arabian crude
- 1 spill vol. = max. vol. dispersed by 1 C-130 sortie  
(100,000 gallons, 80% efficiency, 20:1)
- 1 oil thickness = median value 100 $\mu$ m
- No dispersant use as compared to application after 8 and 16 hours
- 2 wind speeds = 5 kts. and 15 kts.
- 2 mixed layer depth (10 and 20 m)
- 3 current speeds = 0, 0.25 kts. up.- and downwind

# RESULTS

Weathering: percent of product remaining

Component	2 hrs. 5kts wind, % left	8 hrs. 5kts wind, % left	16 hrs. 5kts wind, % left
MAHs	85	34	5
2-ring PAHs	99	96	88
3-ring PAH	99	99	97

# RESULTS

## Area impacted > 1 ppb:

- No dispersants: 0.05 sq. km = 12 ac.  
Volume: 50,000 m<sup>3</sup>
- With dispersants: 38 – 108 sq. km  
or 9,400 – 27,000 ac.  
Volume: max. 500,000,000 m<sup>3</sup>

# RESULTS

## Time of maximum areal impact:

- No dispersants: 1 – 13 hours
- With dispersants: 20 – 200 hours

# RESULTS

## Acute toxicity and potential impacts:

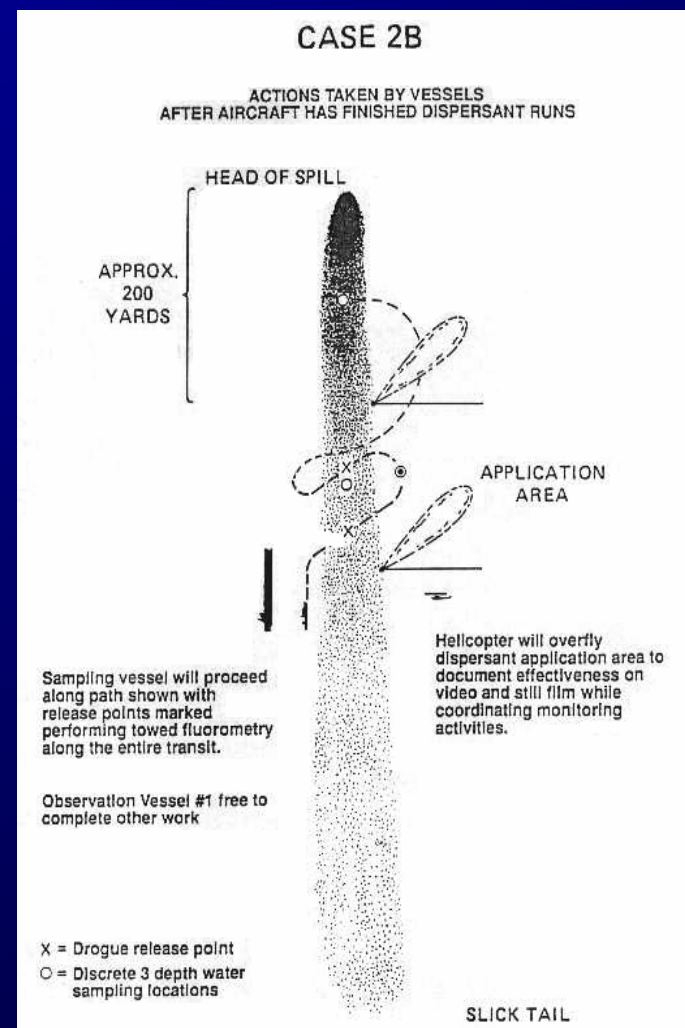
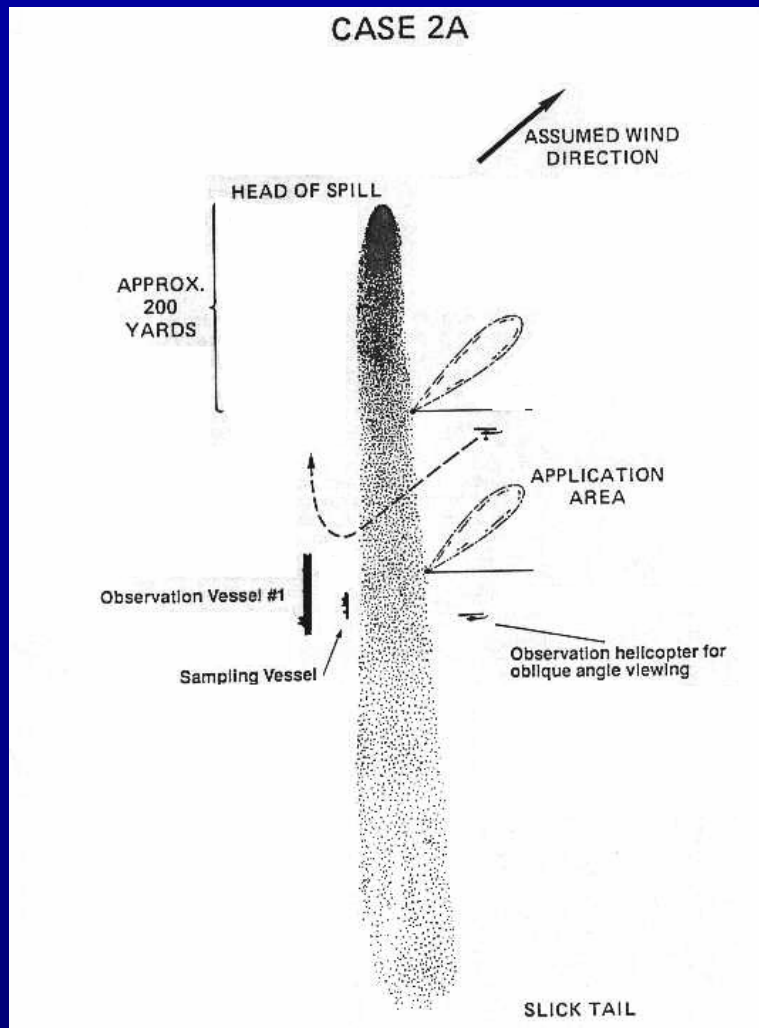
- Sensitive species:  $< 19 \text{ sq. km} = 4,700 \text{ ac.}$   
(5 ppb PAH)
- Average species:  $< 2 \text{ sq. km} = 500 \text{ ac.}$   
(50 ppb PAH)
- Robust species:  $< 0.05 \text{ sq. km} = 12 \text{ ac.}$   
(400 ppb PAH)

# FIELD IMPLEMENTATION OF DOMP

## Important measurements:

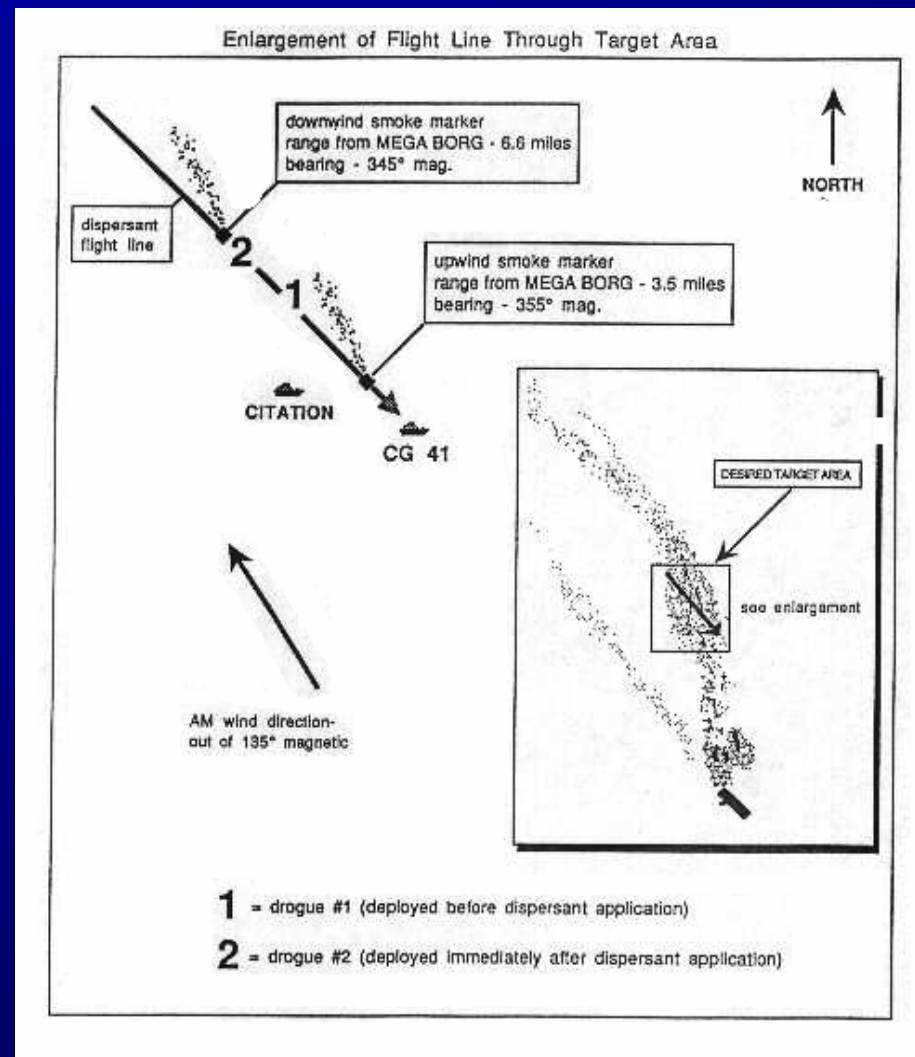
- Near-surface currents (Drogues, CODAR ?)
- Continuous sub-surface plume tracking using SIO towed UV/Fluorometer
- Water samples (Go-Flo bottles & PLVWSS)
- Mixed layer depth (CTD casts)
- Wind speed and direction (direct observation)
- Zooplankton species composition (net tows)

# Approaches to Field Sampling for Impact Monitoring (from Payne et al. 1991)





# Approaches to Field Sampling for Impact Monitoring (from Payne et al. 1993)

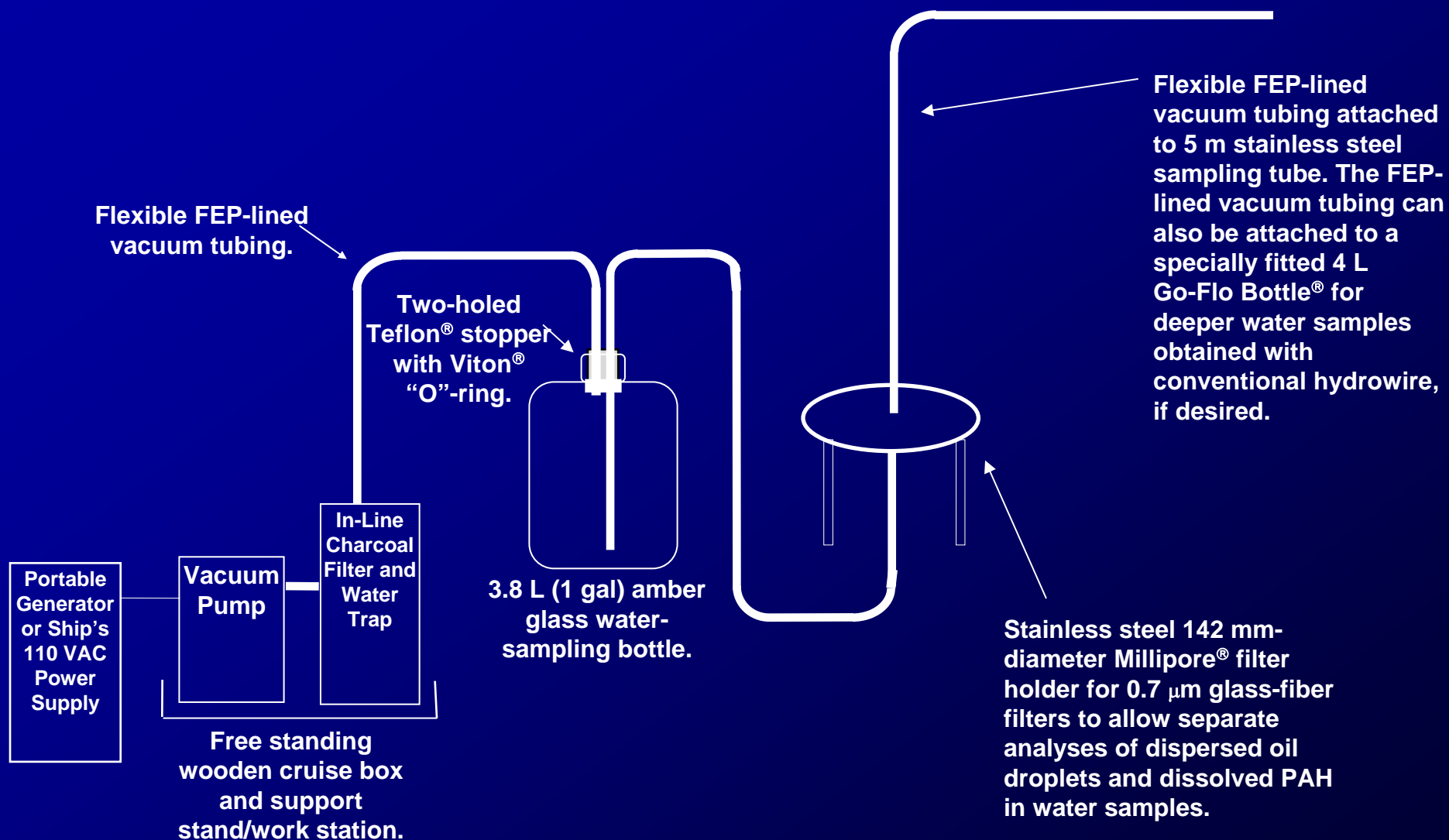


# SIO Towed UV/Fluorometer for Plume Definition and Tracking



- Towed at fixed & variable depths
- Real-time signal fed back to surface vessel
- Towing speeds of 2-15 knots allow rapid measurements
- Minimum plume disturbance

# Schematic diagram of the Portable Large-Volume Water Sampling System (PLVWSS)





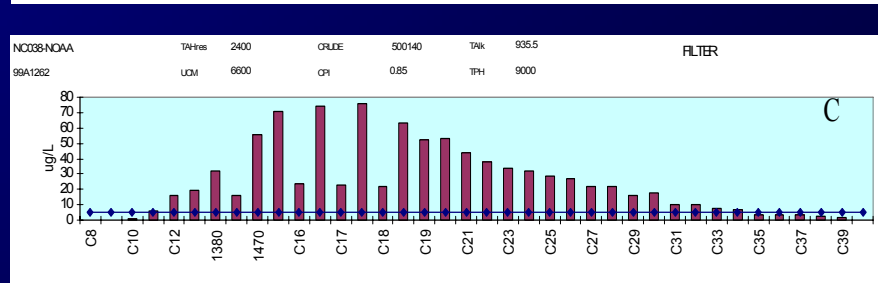
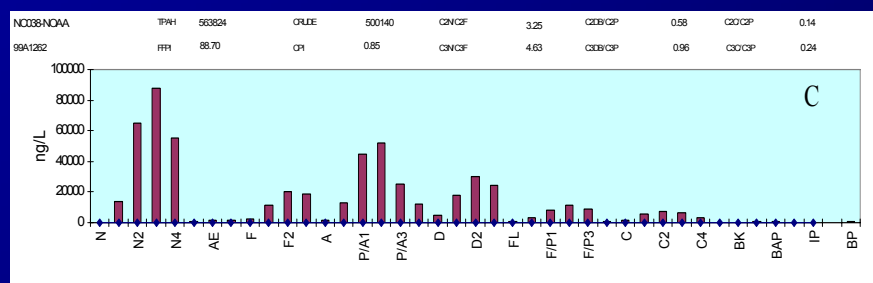
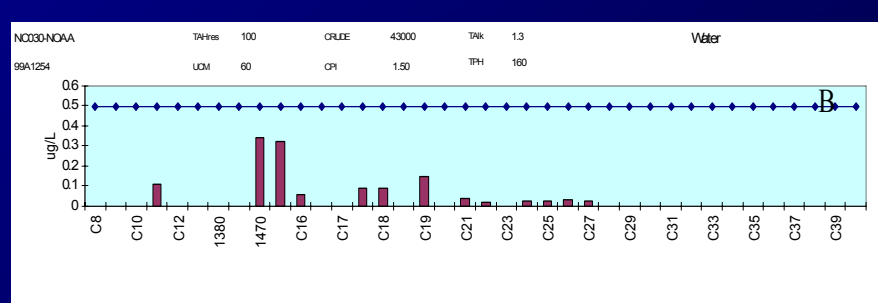
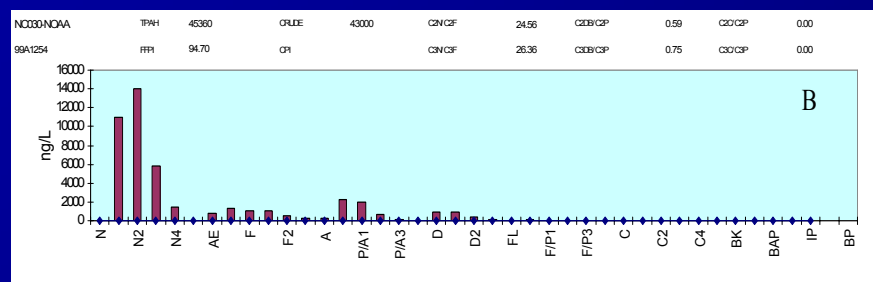
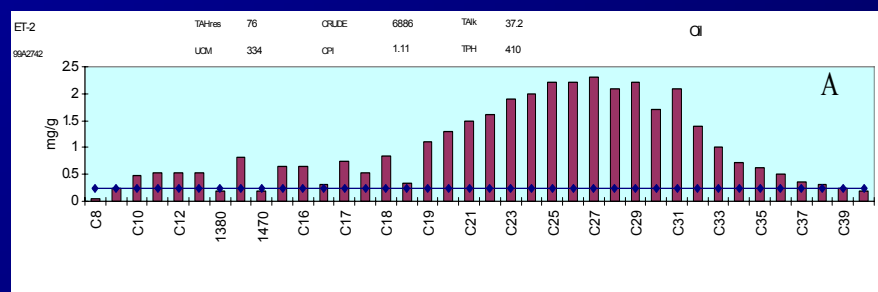
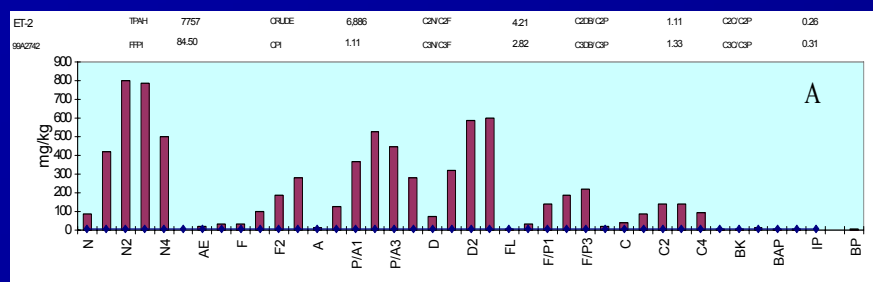
Offshore near-surface and near-bottom water sampling using the PLVWSS and a conventional Go-Flo Bottle® from a chartered vessel-of-opportunity during the *M/V New Carissa* oil spill off of Coos Bay, Oregon. February 1999.





Offshore processing of near-surface and near-bottom water samples collected with a conventional Go-Flo Bottle® during the *M/V New Carissa* oil spill. The sample is pumped directly from the Go-Flo Bottle® into the PLVWSS for separation of dissolved and particulate/oil droplet fractions.

# PAH and SHC Oil Components Measured During the *M/V New Carissa* Spill



PAH Components (mg/Kg and ng/L)

SHC Components (mg/g and  $\mu$ g/L)

(A) Beached Oil; (B) Dissolved Components; & (C) Physically Dispersed Oil Droplets

# Plankton and Neuston Sampling



Oblique “Bongo” net tows sample the water column.



The floating “Manta” net collects surface samples.

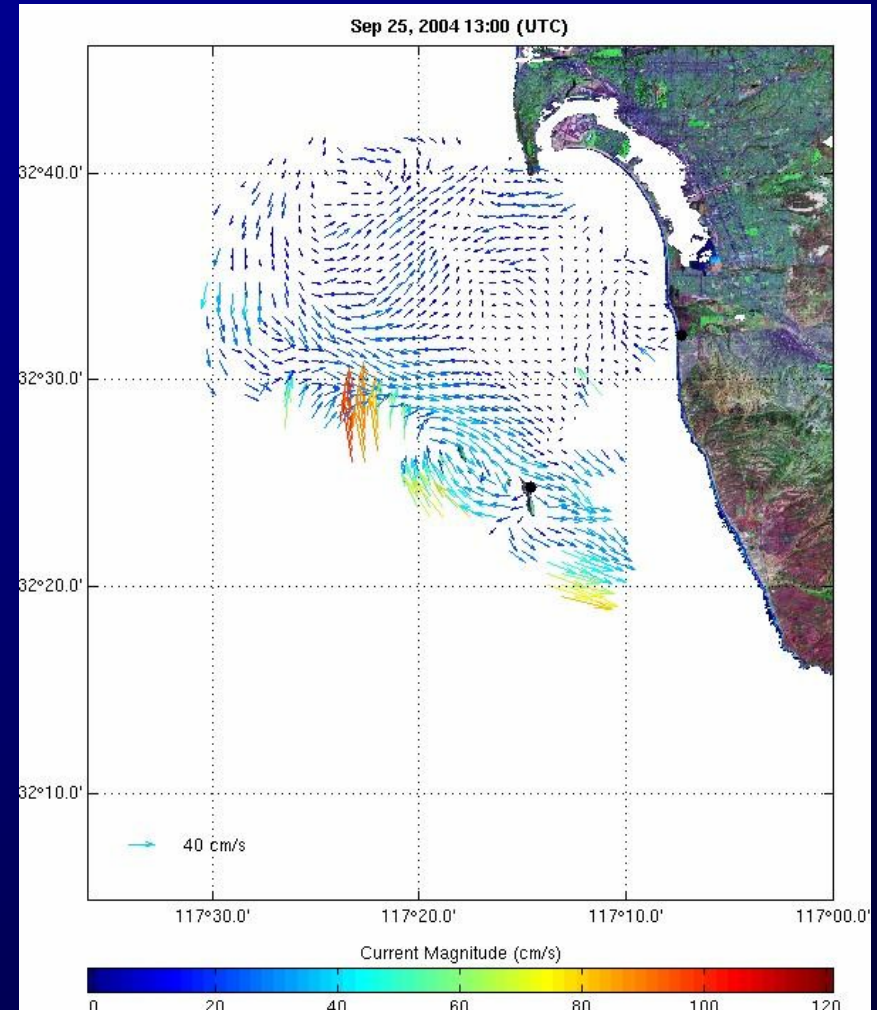
# Plankton Exposure Assessment

- Don't sample in oil slick or dispersed oil plume.
- Sample in uncontaminated adjacent waters for documentation of species and age-group composition.
- Complete separate tows for collection of live zooplankton and egg samples for later laboratory toxicity studies at field-observed PAH and oil-droplet concentrations.
- Can be completed during or following the emergency phase of field operations.



# FIELD VALIDATION OF DOMP

- OSPR-funded shake-down cruises to validate DOMP sampling approach.
- Simulated dispersed oil plume (fluorescein dye).
- Integration of SIMAP and Coastal Ocean Dynamic Applications Radar (CODAR).



# CONCLUDING THOUGHTS

- Patchy distribution of dispersed oil droplets and dissolved components complicates sampling.
- DOMP approach is based on experience from *Pac Baroness* and *Mega Borg* spill-of-opportunity studies.
- Plume sampling would be impossible without subsurface drogues and real-time UV/Fluorescence measurements.
- PLVWSS allows assessment of dissolved PAH vs. oil-droplets and direct comparison to SIMAP predictions.
- Biological injury assessment for zooplankton and eggs drifting with dispersed oil plume (potential longer duration exposure).
- Testing field approach with shake-down cruises and dye studies.

# Questions ?



## Thank you !

